Volume 5 ▪ Issue 4 ▪ February 2012

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Ministry of New and Renewable Energy
Government of India

Renewable Energy
Akshay Urja

www.mnre.gov.in

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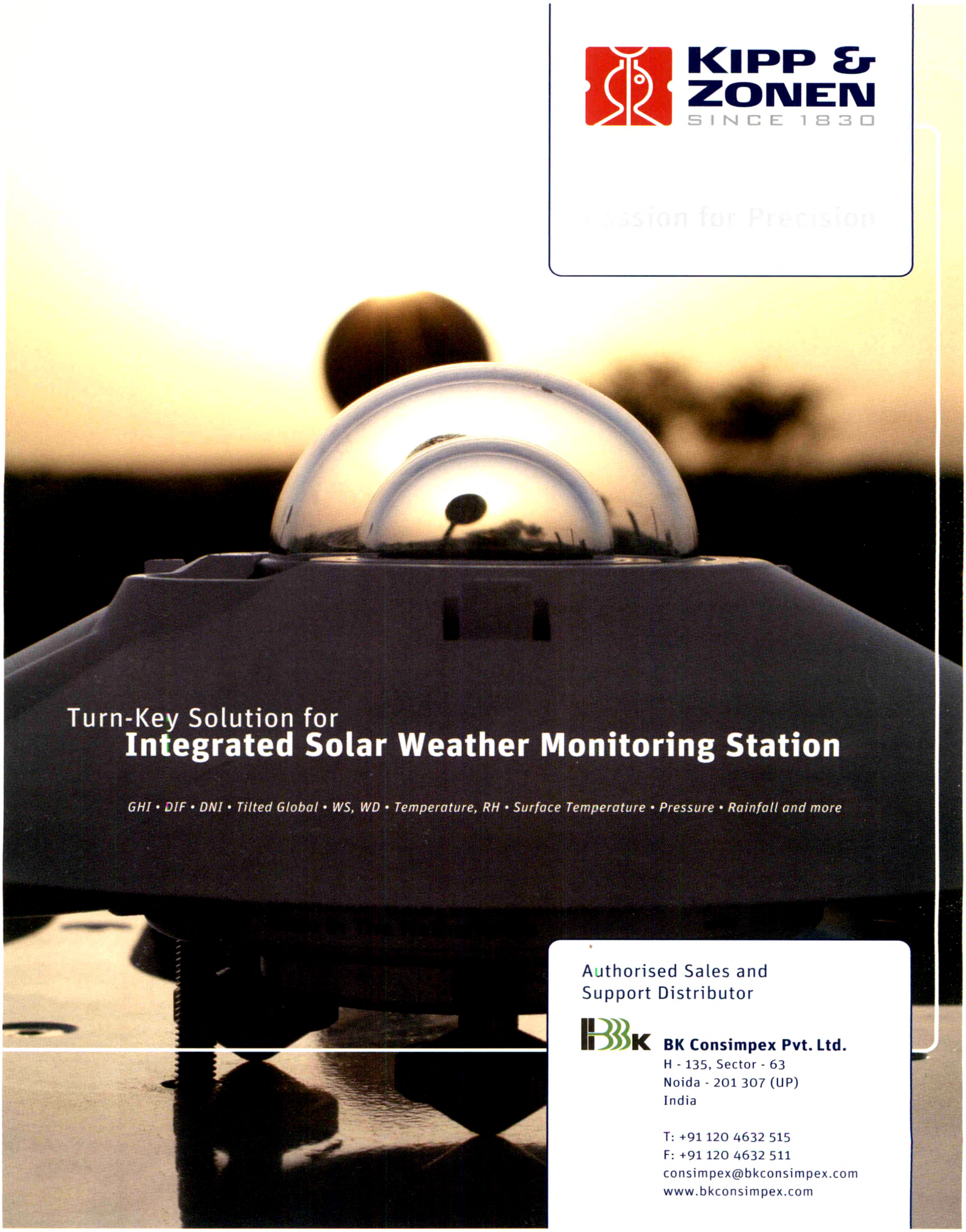
ENERGY ACCESS THROUGH RENEWABLES



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Renewable Energy
Akshay Urja

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February 2012

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4

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Cover Photo: Students at SPRERI Open House 2012 working on solar panels at the exhibition.

Disclaimer: The views expressed by authors including those of the editor in this newsletter are not

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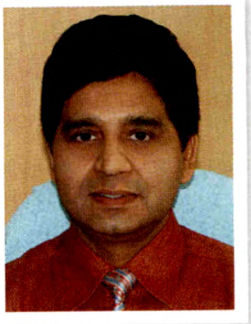
From the Editor's Desk



Dear Readers,

You will be happy to know that grid interactive renewable power is spreading its wings slowly and surely in our country. Very soon it is going to touch the 25,000 MW mark as the present installation has already reached over 23,200 MW. This is about 11.5 per cent of the total installed capacity of electricity generation from all resources. Wind power is the pioneer with over 16000 MW followed by small hydro power (3300 MW), biomass power (over 3000 MW) and surprisingly solar power with about 481 MW. The growth of renewable power has increased more than five times from 2 per cent to about 11.5 per cent in the last one decade. This has been possible due to recognition of the need for power generation from all resources, active participation of the private sector and conducive policy-regimes.

The growth of renewable power is being further augmented by supporting mechanisms like Renewable Energy Certificates (REC) and the Renewable Portfolio Obligations (RPO). The Central Electricity Regulatory Commission (CERC) has notified its Regulation on REC in fulfillment of its mandate to promote renewable sources of energy and development of market in electricity. The framework of the REC is expected to give the much needed push to the Renewable Power in the country. Further, the Renewable Portfolio Obligation also known as Renewable Portfolio Standards generally places an obligation on electricity supply companies to produce/consume a specified fraction of their electricity consumption from renewable energy sources.

Although, a number of renewable energy devices are available in the country, the sale of renewable products in local shops is still not taking shape. The sale of renewable energy products through a network of dealers in shops/showrooms across the country is needed to make the use of renewable energy popular among users.

In the present issue, the overall scenario of renewables in the last three decades in India has been presented. This issue also contains interesting success stories on renewables besides, other regular features. Please send your opinions and feedback to make Akshay Urja a more meaningful publication.

Happy reading!

अक्षय ऊर्जा से देश विकास

AKTripathi

ARUN K TRIPATHI
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Letters to the Editor

We would like to introduce ourselves as SRC Green Power Pvt Ltd located at Chennai. We are the manufacturers of Wind Energy Turbines and accessories. We have plans to promote our products in domestic and international markets. We wish to subscribe your journal. Please advise us on the formalities to go ahead further. Looking forward to hear from you soon.

Karthikeyan
SRC Green Power Pvt Ltd
Chennai

I am interested in New & Renewable Energy Sources as I teach this course to my postgraduate students at the Postgraduate Department of Botany, Ranchi Women's College, Ranchi University, Ranchi.

Dr. (Mrs) Madhavi Srivastava
Ranchi, Jharkhand

It was a pleasure to receive the Akshay Urja Newsletter, October 2011 Vol. 5, Issue 2. The contents in the Akshay Urja magazine are very informative as well as useful to our students, faculty and staff members. It is helping to spread awareness on renewable energy and technology. Thanking you in anticipation.

Librarian, Krishna Girls
Engineering College
Kanpur, Uttar Pradesh

I read Akshay Urja December Issue. I found it very useful and informative. Today renewable energy is the need of the hour. You are doing a good job by making renewable energy popular among people. This is very popular and widely circulated magazine among all walks of life of society. Please keep doing the good job to promote green and clean energy.

Deepak Rawat
Pauri Garhwal, Uttrakhand

I am very happy to inform you that I am getting the magazine regularly. The magazine is very useful and informative. The editorial of the newsletter is very knowledgeful. Its contents are quite impressive. I would like to congratulate you for the effort in making the magazine interesting.

Hemant Kumar Binwal
Director (Vigyan Udday Club)
Champawat, Uttrakhand

I am an employee of Power Finance Corporation and working in the power sector. The magazine Akshay Urja was very useful and I would like to request you to kindly send me the hard copies at the following address.

Sanjay Nayak
Gurgaon, Haryana

I am an owner of an Akshay Urja shop situated in Buxar town in Buxar district in Bihar. I would request you to please send the Akshay Urja Newsletter as it is very useful to know about the latest informations, inventions and government planning regarding renewable energy resources. Visitors in our shop also read and get to know about renewable energy and facilities given to the citizens.

Suresh Kumar Singh
Akhand Jyoti Akshay Urja
Shop, Buxar, Bihar

I was really delighted to read the article "Let's not waste our waste" in the December 2011 issue of Akshay Urja. Disposing of the waste materials is the greatest headache throughout the world. If it is properly disposed, no doubt every one in the world will lead a happy, clean and green life. Bio-methanation is the only source to attain this. In our Periyar Maniammai University in Thanjavur, Tamil Nadu, we are successfully working on Bio-methanation processes. Further, we also work as a nodal agency for other institutions.

Dr K Swaminathan
Additional Registrar,
PM University, Tamil Nadu

अक्षय ऊर्जा दिसम्बर अंक पढ़कर बहुत अच्छा लगा। देश में अक्षय ऊर्जा के क्षेत्र में काफी प्रगति हो रही है तथा अलग से कुछ और प्रयास कर के इस क्षेत्र में हम लोग उन अग्रणी देशों की दौड़ में शामिल हो सकते हैं जो अक्षय ऊर्जा के क्षेत्र में पहले से ही काफी प्रगति कर चुके हैं। इस तरह की जानकारियों से पहले हम लोग अनजान थे, लेकिन अक्षय ऊर्जा पत्रिका से हमें ज्ञान मिलता रहता है। इसके लिए आप लोगों का धन्यवाद।

सोनू नेगी,
संगलाकोटी, पौड़ी गढ़वाल,
उत्तराखंड

अक्षय ऊर्जा अंक दिसम्बर पढ़ा जो बायोमास पर फोकस था। बहुत अच्छा एवं जानकारी पूर्ण लगा। यह हमारे ग्रामीण क्षेत्रों के लिए वरदान हो सकता है। भारत में बायोमास से विद्युत एक समीक्षा काफी उपयोगी एवं ज्ञानवर्द्धक लगा। कृपया बायोगैस के संबंध में विशेष जानकारी प्रकाशित करें। सोलर एनर्जी के बारे में बाजार का तुलनात्मक अध्ययन भी पेश करें ताकि पाठकों को इन्हें प्रयोग में लाने में सहुलियत मिल सके।

सहदेव सहगल
कानपुर, उत्तर प्रदेश

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja will make every effort to make this newsletter highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in terms of content and presentation. **Editor: Akshay Urja**

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The Ministry has taken-up the initiative to meet the increasing demand of manpower in the field of new and renewable energy.

A pilot 20 kW SPV rooftop power plant was installed atop the MNRE Building in October 2010.

Access to clean energy facilitates empowerment of women in rural India and renewable energy provides the most sustainable option.

Dr. Farooq Abdullah Inaugurates 'Teach A 1000 Teachers' Training Programme on Solar PV

MINISTRY OF NEW & RENEWABLE ENERGY
GOVERNMENT OF INDIA
NEW DELHI

Minister of New and Renewable Energy Dr. Farooq Abdullah inaugurated the 'Teach a 1000 Teachers' training programme on Solar Photovoltaics (SPV) being conducted at IIT-Bombay through video conferencing in New Delhi on the 12th of December 2011. The programme is being conducted simultaneously at 35 'remote centres' scattered across the country. A 10-day workshop titled 'SPV: Fundamentals, Technologies and Applications' was organised under the programme from 12th to 22nd December 2011, during which the faculty of IIT took lectures through indigenously developed tutorial and laboratory sessions.The programme organised by the National Centre for Photovoltaic Research and Education at IIT-Bombay jointly with the Ministry of New and Renewable Energy and Ministry of Human Resource Development aims at developing manpower for successful implementation of the Jawaharlal Nehru National Solar Mission.

Speaking on the occasion, Dr. Farooq Abdullah said that this commendable step will help in meeting the energy needs of rural areas through the use of renewable energy sources. He called upon the teachers undergoing training to work hard to make the programme a success. Elaborating upon the achievements under the Jawaharlal Nehru National Solar Mission, Dr. Abdullah said that project selection of 800 MW through tariff discounting bidding has substantially helped in reducing the tariff. He added that the Ministry of New and Renewable Energy has also initiated the process for selection of another 350 MW in Batch-II during 2011-12. The results of the bidding of this batch have just come and further reduction in average tariff of solar power to Rs. 8.77 per unit has been offered.

Dr. Abdullah informed that by now over 180 MW capacity grid power projects have been commissioned under various schemes and by March, 2012 about 400 MW capacity projects will be commissioned in the country. He added that in the area of off-grid solar by now more than 67 MW capacity projects have been sanctioned which is expected to go up to 100 MW by March, 2013. He said about 5 million sq. m. solar thermal collector area has also been installed by now. The Minister said that in order to obtain quality radiation data for solar thermal projects, 51 new radiation data monitoring centres have been set up besides the centres already operated by India Meteorological Department (IMD).

The Jawaharlal Nehru National Solar Mission launched by the Prime Minister of India on January 11, 2010, provides a policy framework for scaling up deployment of solar energy technologies in the country with a focus on research and development and indigenous manufacturing for reduction of cost to achieve grid parity by 2022.

www.indianexpress.com,
19 January 2012.

India and Norway to Enhance Cooperation in the Field of Renewable Energy

The Norwegian Minister for Environment and International Cooperation, Mr. Erik Solheim called on the Union Minister of New and Renewable Energy, Dr. Farooq Abdullah in New Delhi on 2 February 2012. Both the Ministers were accompanied by high level delegations. During the talks Dr. Abdullah said that the Indian Government is taking an active interest in setting up the proposed fund in collaboration with the DFID, UK and Norway for promoting off-grid solutions in the field of renewable energy. Highlighting the achievements made by India in the area of solar and wind energy, Dr. Abdullah said that renewable energy can substantially reduce consumption of kerosene and diesel. The Indian side expressed interest in collaborating with Norway in the field of off-shore wind energy. Norwegian side while welcoming this, invited a team from India to study the floating barrage wind farms in Norway.

www.constructionweekonline.in
3 February 2012.

India Offers Assistance to Mauritius in Tapping Renewable Energy

India has offered help to Mauritius in developing its renewable energy sector.

The Minister of New and Renewable Energy, Dr. Farooq Abdullah, during his recent visit to Mauritius called on the Prime Minister of Mauritius, Dr. Navinchandra Ramgoolam, and had bilateral meetings with the Deputy PM and Minister of Energy, Dr. A. R. Beebeejaun, and other Ministers of Mauritius. Dr. Abdullah offered assistance to the island nation in tapping its renewable energy resources and offered to scale-up Indian initiatives in capacity building and support in design and policy framework for renewable energy initiative in Mauritius. He made a special reference to the traditional and warm ties between the two countries and of the multi-cultural and diverse society that has been created as a result of emigration of hundreds of thousands of Indians to Mauritius. The Mauritian side thanked India for its support in imparting training to Mauritian scientists and technicians in solar and wind energy.

Dr. Abdullah also visited the Apravassi Ghat,now a UNESCO world heritage site, the first point of landing for the indentured labourers who left India to work in Mauritius.

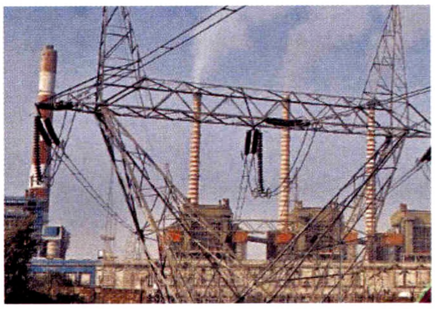
www.investinindia.com,
24 January 2012.

Dantewada : Education City with Solar Power

A Rs 100 crore Education City is coming up at Gidam on the Jagdalpur-Bijapur NH-30, Chhattisgarh. It will have around 15 institutes including an engineering college, an ITI, a sports school, a tribal girls' school, a Kasturba Gandhi Vidyalaya, besides a residential school for children orphaned in the naxal violence. The entire campus and its operations including some institutes are all solar powered. The remaining institutes will all become operational in two years time. The Education City will cater to over 5,000 students. O. P. Chaudhary, the Dantewada Collector known to have taken many innovative initiatives to provide quality education to tribals, has initiated this project. According to the Government data Dantewada district has been among the top performers in utilisation of Integrated Action Plan funds given to naxal affected areas.

www.indianexpress.com,
19 January 2012.

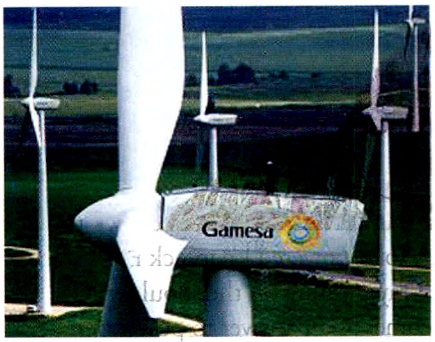
NTPC Signs Purchase Pact for Solar Power



NTPC Ltd has signed a power purchase agreement (PPA) with MP Tradeco in Bhopal for the supply of power from 50 MW SPV Power Plant to be set up at Rajgarh in Madhya Pradesh, expected to be commissioned by the year 2013. The company has also finalised plans to set up a 25-MW SPV Project close to the Ramagundam super thermal power plant with an outlay of about Rs 140 crore for phase 1 of the 10 MW project. The company plans to install all of the 25 MW at the site in MP by 2013. The company's medium term plan is to have an installed capacity of about 1,000 MW of energy from non-conventional energy sources including SPV, solar thermal and wind energy farms.

www.indiainfoline.com
30 December 2011.

Gamesa Commissions Blade Unit in Gujarat



Global wind energy major Gamesa has commissioned a Rs 175 crore blade making factory at Vadodara, Gujarat. The plant, scheduled to produce 390 blades in 2013, will make components for its 850 kW and 2 MW turbine systems. The manufacturing facility, which has produced its first blade for the 850 kW turbine, will primarily route supplies to the northern States, including Gujarat, Rajasthan, Madhya Pradesh and Maharashtra. This is part of the €60 million investments Gamesa had announced in March, 2011 to strengthen its manufacturing base in India to tap rising demand in the wind energy market. The company intends to complete its investment plans by building a factory to produce nacelles (a cover that houses all generating components in a wind turbine) in Tamil Nadu. Gamesa also operates as a wind farm developer in India with a combined capacity exceeding 2,100 MW. In May 2011, Gamesa Wind Turbines, the Indian subsidiary of Gamesa Corporation, signed a $2 billion agreement with Caparo Energy

India for supply and commissioning 2,000 MW of turbine capacity in India.
www.thehindubusinessline.com, 11 January 2012.

New Solar-Powered Sprayer

A solar-powered knapsack manual sprayer (hung on the shoulders) comes as an answer to power deficient villages in the state of Tamil Nadu. Priced at Rs. 3,500 the device has been developed by Mr David Raja Beleau, Assistant Director of Horticulture Kadayam, Tamil Nadu. The device has an electric motor operated by a 12 V 7 Amp. rechargeable battery, with a capacity of 16 litres. Once charged during the night, it can be operated for nearly eight hours and there is no need for petrol or any other fuel to operate the device. While spraying in the field, the battery can be further charged by switching on the solar power system attached to the sprayer. The solar panel is attached to a helmet and connected to the battery. The solar power system in the sprayer can also facilitate lighting of 'wireless light traps' that control insect pests and reduces the number of insecticide sprays by fifty per cent, cutting the cost of cultivation for the farmer. This reduces pesticide residue in the products thereby improving the quality of the products. The light traps can also control mosquitoes effectively. In terms of rising fuel prices the device helps cut the cost of cultivation and is user-friendly. The new model eliminates the erstwhile problems of longevity and management and is a dream equipment for the farmers in Tirunelveli and Kolli hills.
www.thehindu.com, 29 December 2011.

NVVN Guidelines for Batch II Phase I Solar Projects

NTPC Vidyut Vyapar Nigam (NVVN) expects to sign power purchase agreements with 22 companies by early 2012 to develop 350 MW of grid-connected solar photovoltaic energy. The companies include GAIL (India), Welspun Solar, Mahindra Solar One, Enfield Infrastructure, Essel Infraprojects, Azure Power India and French firm Fonroche Energie S.A.S. The trading arm of NTPC, NVVN has been designated as the nodal agency for sale and purchase of grid-connected solar power under Phase-1 of the Jawaharlal Nehru National Solar Mission. Last December, NVVN had issued letters of intent to the short-listed developers for the second batch of Phase-1. The other companies short-listed include Solairedirect SA, SunBorne Energy Services, Sujana Towers, and Green Infra Solar Farms. Of the 28 projects for which letters of intent have been issued to these companies, 24 are in Rajasthan, two in Maharashtra, and one each in Andhra Pradesh and Tamil Nadu. Over 150 companies, including Reliance (Anil Ambani Group), Lanco, Moser Baer and the Tatas, had evinced interest in developing large solar photovoltaic projects of up to 20 MW. Request for selections were received for 218 projects for over 2,500 MW, much higher than the 350 MW offered.

Developers offering the best discount on tariff fixed by the regulatory commission for photovoltaic projects were short-listed for the second batch and letters of intent issued. The tariff quoted were presumably amongst the lowest in the world with an average Rs 8.77 a unit, with the lowest bid being Rs 7.49 a unit. Compared with the tariffs of over Rs 18 a unit at the start of the Mission, this is a reduction of more than 50 per cent, the official added.

The National Solar Mission envisages the implementation of the solar programme (thermal and photovoltaic), including utility grid solar power in three phases - first phase up to 2013 (1,100 MW), second phase up to 2017 (4,000 MW), and third phase up to 2022 (20,000 MW).
www.bharatvasandani.wordpress.com, 10 October 2011.

Renewable Energy Certificate Prices Hit a New High

RENEWABLE ENERGY
CERTIFICATE
1,382,603 kWh
K Line Americas
1,546,939 lbs. of CO_2

December 2011 mapped a new high in renewable energy certificates, both in volumes and in prices. As many as 1,11,621 RECs were traded on the two exchanges – Indian Energy Exchange (IEX) and Power Exchange of India Ltd (PXIL). IEX accounted for 95 per cent of the trading and saw the number of RECs traded on it cross the 100,000-mark (105,942 RECs were traded on the exchange). The average prices were Rs 2,950 for each REC on both the exchanges. RECs are generation-based 'certificates' awarded (electronically, in demat form) to those who generate electricity from renewable sources. Certificates are tradeable on the exchanges and are bought by 'obligated entities'. Trading in RECs happens on the last Wednesday of each month and the cleared volumes have been picking up month after month. In September, 46,363 RECs were traded, which was more than twice as much as in the previous month. In October, the number rose to 95,504, and to 105,000 in November.

However, uptill now, close to 220,000 RECs have been issued, which means that half the available certificates only got traded. Also experts have commented that the price hike has been very marginal, which reflects that the prices are very near their maturity. The future market movement, they add, will depend heavily upon how the new demand shapes up.

www.www.infraline.com, 5 September 2011.

Tata Power to Buy Out BP in Solar JV

The Tata Group and London-based BP Plc are ending their joint production of photovoltaic cells and modules, a venture that brought the two industry giants together 22 years ago. The groups have, since 1989 jointly invested crores of rupees in manufacturing lines for solar cell and modules in Bangalore and have seen the venture, called Tata BP Solar, grow from a modest turnover of Rs 1.6 crore in 1991-92 to Rs 906 crore in 2010-11. In a statement, Tata Group firm Tata Power Company said that it is taking complete control of the South-based Tata BP Solar by buying out BP Alternative Energy Holdings' 51 per cent stake. It, however, didn't disclose the value of the transaction, which requires approval from the Reserve Bank of India and Competition Commission of India (CCI), after the merger and acquisition regime came into effect from June. The stake purchase by Tata Power is part of its strategy to consolidate its presence in the Indian solar energy sector, which is expected to grow from 800 MW to 1200 MW in 2014-15. BP, on the other hand, is gradually exiting the solar business globally as stiff competition especially from China takes a toll on its margins.

www.timesofindia.indiatimes.com, 28 December 2011.

Draft RPO in Andhra

The Andhra Pradesh Electricity Regulatory Commission (APERC) has come out with its draft regulations for 'renewable purchase obligation' (RPO). Andhra Pradesh is among the last few States – in fact, the 26th State – to come out with RPO regulations. AP's draft regulations impose an obligation on electricity distribution companies in the State, captive power projects and 'open access consumers'. These 'obligated entities' need to purchase 5 per cent of the consumption (or sales) from renewable sources. Of this 5 per cent, the RPO target shall be inclusive of 0.25 per cent solar power specific targets. The regulations apply for the period between April 1, 2014 and March 31, 2019.

www.reconnectenergy.com, 26 December 2011.

Plan to Tap Solar Power at Vikas Bhawan, Secretariat

Delhi government is working to introduce solar energy into its own system. The Secretariat building and Vikas Bhawan will shortly be drawing a small percentage of their power from rooftop solar panels while a study is being carried out to assess the feasibility of providing solar power to government schools and hospitals. Environment secretary Keshav Chandra said that the combined capacity of the two projects will be 135kW. Vikas Bhawan will get a 100kW system while the secretariat will have a 35kW system. This would constitute a small percentage of power requirements for the two buildings but at least some part of the energy consumed will be through renewable sources. A feasibility study is underway to assess the potential of setting up rooftop solar power projects at 25 government schools and 10 government hospitals. Delhi has a shortage of land and the only place available for any substantial solar plant is the rooftops. The rooftop policy was scrapped as it is difficult to keep a tab on the sources of power production.

www.timesofindia.com, 12 February, 2012

UN Panel Urges World at Rio to Launch Energy Fixes

A high-profile 22-member U.N. panel created in August 2010 and headed by the presidents of Finland and South Africa hopes to spark an 'ever-green' energy revolution later this year in Brazil using a general roadmap it presented on how world leaders could wean the world off fossil fuels. The panel urges that nations fully integrate the social and environmental costs of their commerce into the prices and measures of their economic goods and services. They also call for the creation of a global education fund, improvements in human rights and more programmes to empower women and to work towards 'ever-green revolution' for the 21st century by spending more on agricultural research, protecting imperiled plant and animal species, conserving land and water and fighting pollution. It also encourages the creation of regional oceans and coastal management bodies that protect world fisheries supplying 170 million jobs and daily protein for about one in five people on the planet.

"This report makes the alarming point that while we are already exceeding the Earth's capacity to support us, by 2030 we will need 50 per cent more food, 45 per cent more energy and 30 per cent more water than we do today," said, Jim Leape, Director General of Swizz-based WWF International.

But in a statement the panel also criticized the U.N. report because it "fails to suggest any concrete, time-bound commitments for progress, leaving policies open to governments to implement as they saw fit."

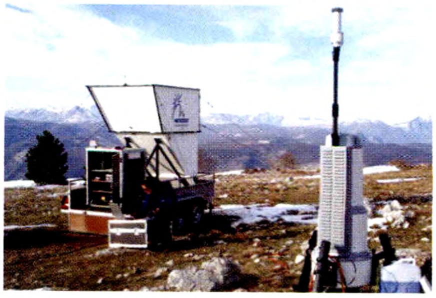
www.energynewswecimc@gmail.com
1 February 2012

Tropical Rainforests Store More Carbon than Previously Thought

Tropical rainforests together with our oceans are the largest carbon sinkers. The deforestation of tropical rainforests means less trees to store carbon, it also represents a major source of carbon emissions by releasing approximately 1.1 billion tons of carbon into the atmosphere each year. However the good news comes from the study recently published in Nature Climate Change which concludes that tropical vegetation contains 21 per cent more carbon than previously thought. In this latest study, the scientists have created a carbon density map for the tropics with a great level of consistency and accuracy. Among other things they were able to discover that tropical forests in America store around 118 billion tons of carbon, an almost 20 per cent more than that shown by previous studies. It is of vital importance to have reliable estimates of carbon storage because they are critical to learn about the amount of total carbon released into the atmosphere by changes in land cover and land use.

www.climatechangearticles.blogspot.in
31 January 2012.

Wind Projects Maximise Value of Remote Sensing



As SODAR (SOnic Detection And Ranging) and LIDAR (LIght Detection and Ranging) technologies mature, more developers are using them to support wind resource assessments. These remote sensing instruments are relatively easy to use and move from site to site. They provide hub-height wind speeds and direction, vertical wind speeds, and wind shear and veer above the heights of typical meteorological tower (met mast) measurements. They may also provide some measure of turbulence levels. In an energy assessment, remote sensing data may be used to evaluate the accuracy of extrapolations from tower data; shear coefficients to be used with tower data; hub-height wind speeds and directions; and wind resource variability across the site. How the data used in an energy assessment will depend on the quality, quantity and representativeness of the validated data. The degree to which the data will improve or reduce, that uncertainty of the energy assessment will depend, among other factors, on the data recovery and its correlation to the nearby met tower data, the data collection durations and the data collection locations relative to meteorological tower and proposed turbine locations. Other project characteristics will also determine the impact of remote sensing data on an energy assessment. For example, if there is a little uncertainty in the energy assessment without remote sensing measurements, then remote sensing measurements may have a marginal impact on the overall assessment due to the uncertainties inherent in the remote sensing data. Seasonal variability of the atmospheric conditions at the project may limit the impact of short-term remote sensing measurements on the energy estimate or its uncertainty.

Energy assessments are usually based on one or more years of met tower data from more than one met towers within a project area. These data are then used to estimate the wind resource at turbine locations and hub heights. There may be enough topographic variability of the wind resource that the estimates of wind speeds at some turbine locations are quite uncertain. There may also be uncertainty as to whether the shear exponent as measured using tower data represents the shear behaviour above the tower or at the proposed locations.

www.renewableenergyworld.com
29 November, 2011

World's Largest Solar Plant Powers Up

Just under a month ago, on an empty mountain plateau in Andalusia, Spain, the last of 600,000 parabolic mirrors were connected, and Andasol, the world's largest solar power station, became operational. It is, as it glints in the Spanish sun, a shining example – literally – of what renewable energy offers. A joint venture by four German companies and with a €350m (£293bn) investment, the Project is computed to capture more solar energy than the entire Saudi Arabian peninsula. Other plus points include an ample underground spring system, which supplies water for the turbines, as well as 2,000 hours of sunlight per annum. Thereby if a conveniently close high-voltage power line was an indispensable factor, so too was the degree of local government support.

www.independent.co.uk,
1 January 2012.

Energy Saving Trust, UK, Studies Solar Water Heaters

Biggest ever study of solar water heating systems in UK shows range of performance. In fact properly installed systems can provide 60 per cent of home's hot water needs. The key performance factors were identified as water volume, insulation and heat levels required. The Energy Saving Trust has concluded the largest ever in- study of the systems completed in the UK and Ireland and the trial found that the quality of system installations and the way householders use their solar water heating system in terms of volume of hot-water use, timing of back-up heating, and temperatures required is critical in achieving the best results. The Trust is calling for a thorough review of industry guidelines and standards to ensure that all issues uncovered in the trial are fully addressed and householders interested in solar water heating can get the biggest possible gains from their investment. Introducing solar water heating systems into households represents over 6 per cent of the Europe-wide 2020 renewables target – and the technology is one of the more established domestic renewables found in the UK.

There has been a steady trickle of installations for a number of years as a small- scale industry, but now the market is growing significantly – in 2010 growing by 18.1 per cent, ahead of a 13.1 per cent growth in Europe. Solar water heating has been supported by schemes like the previous Low Carbon Buildings Programme and the current Renewable Heat Premium Payment (RHPP) scheme. To date, over 2,000 RHPP vouchers have been claimed towards the cost of heating technologies – 31 per cent solar water heating systems.

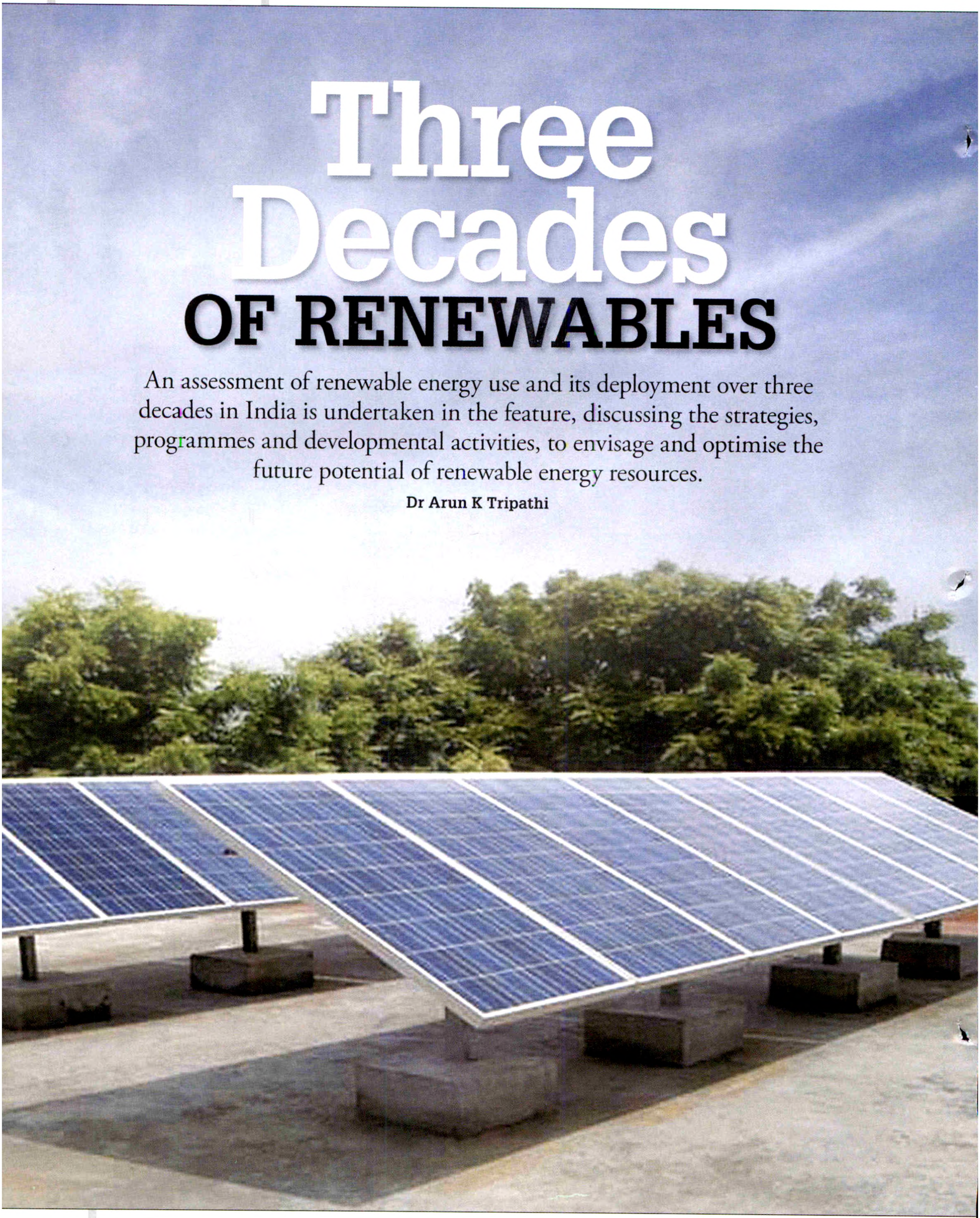
The study found, over 88 sites, systems providing as much as 60 per cent of homes' hot water – but also found one example providing 9 per cent. The median across all the homes was 39 per cent. Solar water heating systems are typically designed to provide half of the average home's hot water needs.The field trial ran over the course of a year from April 2010, and measured the energy delivered by the collector to heat the household's water, the electrical energy required to operate the system pump and control system, and the energy delivered by the back-up heat source – something that is required in all solar thermal systems. The Energy Saving Trust is the UK's leading impartial organisation helping people save energy and reduce carbon emissions.

www. www.solarmash.com,
15 October 2011.

Three Decades OF RENEWABLES

An assessment of renewable energy use and its deployment over three decades in India is undertaken in the feature, discussing the strategies, programmes and developmental activities, to envisage and optimise the future potential of renewable energy resources.

Dr Arun K Tripathi



The power sector in India has grown in terms of its size and coverage, technology, capacity addition and more. As a result, the cumulative installed capacity in the country has reached nearly 1,87,000 MW as against 1300 MW in 1947 with an estimated peak shortage of about 14 per cent.

The journey towards realising the optimal potential of renewable energy in India today spans three very fruitful decades. Renewable energy has carved a niche for itself within the mainstream of energy supply options in the country and has penetrated the bastions of conventional energy supply systems. It is no longer 'alternate energy', but a key component of the solution to the nation's energy needs. The applications of renewable energy are widespread, ranging from electricity supply, cooking and heating, transport, etc.

Relevance of Renewable Energy in India

India is blessed with an abundance of natural resources, like solar, wind and biomass including agricultural residues. Harnessing these resources is the panacea for all its energy related woes particularly in remote and far-flung villages. Renewable energy can play a vital role in meeting the energy requirements in a decentralised manner besides feeding into the national grid, to some extent.

Trends in Renewable Energy Development in India

Grid-interactive renewable power

Grid-interactive renewable power capacity in the country reached 23,130 MW on 31 January 2012 which is about 11.5 per cent of the total grid installed capacity in the country, and contributed to about 4.5 per cent to electricity generation.

> **The data pertaining to the growth of renewable power capacity in the country indicates that the major contributor has been wind power which is about 70 per cent of the total capacity.**

Wind turbines at a wind farm

By the end of the Eleventh Plan period i.e., 31 March 2012, renewable power installed capacity is expected to reach over 24,000 MW. It may also be seen that due to the Jawaharlal Nehru National Solar Mission, the growth of solar power is exponentially high during the Eleventh Plan period.

Off-grid renewable power

Apart from the grid interactive renewable power, ambitious programmes for the deployment of off-grid/distributed

Table 1. Plan wise capacity addition in grid interactive renewable power in India

Resource	Estimated Potential (MW)	Upto 9th Plan - Achievement	10th Plan - Achievement	11th Plan Achievement upto 31.01.2012	Cumulative Achievements upto 31.01.2012
Wind power	48,500	1,667	5,427	9085.00	16179.00
Small Hydro power	15,000	1,438	538	1324.13	3300.13
Biomass power*	23,700	390	795	1910.13	3095.13
Solar power	20-30MW/ sq.km	2	1	478.48	481.48
Waste to Energy	-	-	-	73.66	73.66
Total		**3497**	**6,761**	**12871.40**	**23129.40**

*Note – including biomass power, bagasse cogeneration, urban and industrial waste to energy

> **The renewable energy implementation strategy has shifted from the demonstration and R&D phase in the Sixth and Seventh Plan to the purely commercial strategy in the Eleventh Plan.**

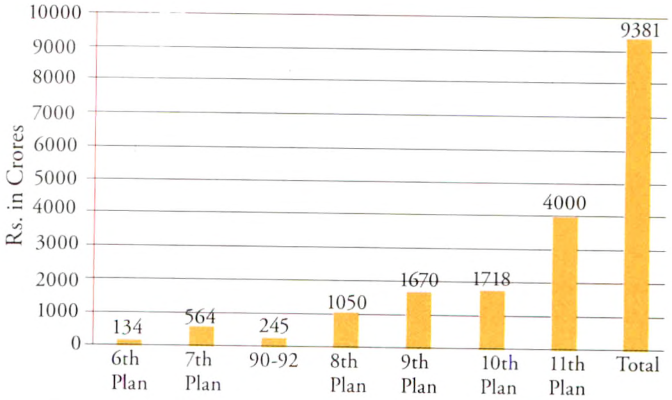
renewable power and decentralised renewable energy have been proposed for rural application. Refer to RE at a glance (page 52) for a summary of the achievements in off-grid distributed renewable power and decentralised energy systems.

Financial Investments in Renewable Energy Sector

The financial allocation for Renewable Energy Sector vis-à-vis the total allocation remains in the range of 0.1 per cent during the Sixth Plan, to 0.45 per cent in the Eleventh Plan period (Table 2). This indicates that although the allocation in the Five Year Plans has not increased significantly, the growth in the renewable energy sector has in fact taken place due to the private sector's participation.

The utilisation of Gross Budgetary Support of Rs. 134 crores in the Sixth Plan in Renewable Energy sector rose to a level of Rs. 1670 crores in the Ninth Plan, 1718 crores in the 10th Plan and is expected to reach 4000 crores in the 11th Plan with the total estimated investment of about Rs. 9381 crore by the end of the 11th Plan (Fig 1). This investment has attracted over 6 times the total investment by private sector participation.

Fig 1: Central Investment in Renewable Energy Sector



Source: MNRE Annual Reports and Five Year Plans

Implementation Strategies over the last Three Decades

The spread of various renewable energy technologies in India has been possible primarily because of a variety of policy and financial support measures. Soft loans, concessional rates of customs duty, exemption from excise duty, and accelerated depreciation benefits to commercial users are some of the incentives available. The subsidy ranges from 20 to 30 per cent in most cases but it reaches up to 90 per cent in special

Table 2. Allocation to Renewable Energy vis-à-vis Conventional Energy Sources

Five Year Plan (Period)	Total Plan Outlay (Rs. in Crore)	Energy Sector Outlay (Rs. in crore) (% of Total)	Percentage share in the total plan allocation			
			Power	Oil/gas	Coal	Renewables
Sixth (1980-85)	109,290	30,751 (28.1)	16.7	7.8	3.5	0.1
Seventh (1985-90)	220,220	61,689 (28.2)	17.4	7.3	3.2	0.3
Eighth (1992-97)	434,100	115.561 (26.5)	18.4	5.5	2.4	0.2
Ninth (1997-02)	8,59,200	2,19,915 (25.6)	14.5	8.6	2.04	0.44
Tenth (2002-2007)	8,93,187	2,86,592 (32.1)	16.05	11.60	3.18	0.80
Eleventh (2002-2012)	21,56,571	623,788 (28.9)	14.16	11.37	2.92	0.45

Source: 6th to 11th Five Year Plans of Planning Commission, New Delhi.

categories. The renewable energy implementation strategy has shifted from the demonstration and R&D phase in the Sixth and Seventh Plan to a purely commercial strategy phase in the Eleventh Plan.

Renewable Portfolio Obligation

Renewable Portfolio Obligation (RPO) also known as Renewable Portfolio Standards (RPS) generally places an obligation on electricity supply companies to produce/ consume a specified fraction of their electricity consumption from renewable energy sources. As per the RPO specified State Electricity Regulatory Commissions, the leading state is Himachal Pradesh (11.10 per cent) followed by Rajasthan (9.5 per cent) and Maharashtra (7 per cent) other states of Gujarat, Uttaranchal, Manipur, Mizoram, Jammu & Kashmir, Uttar Pradesh, Tripura, Jharkhand, Odisha and Assam have 2.8 per cent to 6 per cent fraction of their power utilities coming from renewables.

Renewable Energy Certificates

The Central Electricity Regulatory Commission (CERC) has notified a Regulation on Renewable Energy Certificate (REC) in fulfilment of its mandate to promote renewable sources of energy and development of market in electricity. The framework of the REC is expected to give a push to the renewable energy capacity in the country. About 1065 renewable energy generators or agencies have been registered for trading the RECs and about 731962 RECs have been issued so far in the country of which 609773 RECs have been redeemed.

New Schemes/Programmes

Major initiatives taken by the Ministry include the launch of the Jawaharlal Nehru National Solar Mission (JNNSM), and separate schemes for solar cities, green buildings, human resource developments etc. Under JNNSM, a target of 20,000 MW solar power, 2000 MW off grid solar applications and 7 million sq.m collector area has been set, to be achieved by 2022.

Infrastructure Development

State Nodal Agencies (SNAs) for overall implementation of Renewable Energy programmes in all states and UTs have been established. The Indian Renewable Energy Development Agency has financed over 2000 projects.

Manufacturing Base

Development of a manufacturing base and encouragement to private entrepreneurs for ensuring mass production of renewable energy systems/devices to reduce unit cost, has been a major strategy. With the support of the government, various retail marketing outlets for renewable energy products called Akshay Urja Shops have been opened, and of these 64 shops are operational. Although, the manufacturing base has expanded to a large extent, the retail market of renewable energy products is yet to be developed. The indicative manufacturing base of renewable energy sector is given in Table 3.

> **Overall the renewable energy sector has grown substantially in the country and today renewable power is contributing to about 11.5 per cent of the country's energy demand.**

Table 3. The manufacturing base of the renewable energy sector

Renewable Energy Sector	Nos. of Manufactures
Solar Thermal	221
Solar Photo Voltaic Manufacturers empanelled under Refinancing scheme implemented through NABARD	33
Biomass Gasifier	16
Biogas Plants and Appliances	35
Manufacturers of Small Hydro Power equipment	24
Manufacturers of Wind Turbine	17

Source: MNRE

Conclusion

Overall the renewable energy sector has grown substantially and today renewable power is contributing to about 11.5 per cent in the country's installed power generating capacity. Besides, millions of renewable energy systems and devices are meeting the daily energy requirements of people. However greater involvement of end users and proper retail of renewable energy products for an enhanced outreach and easy access to the common man is the need of the hour. ✪

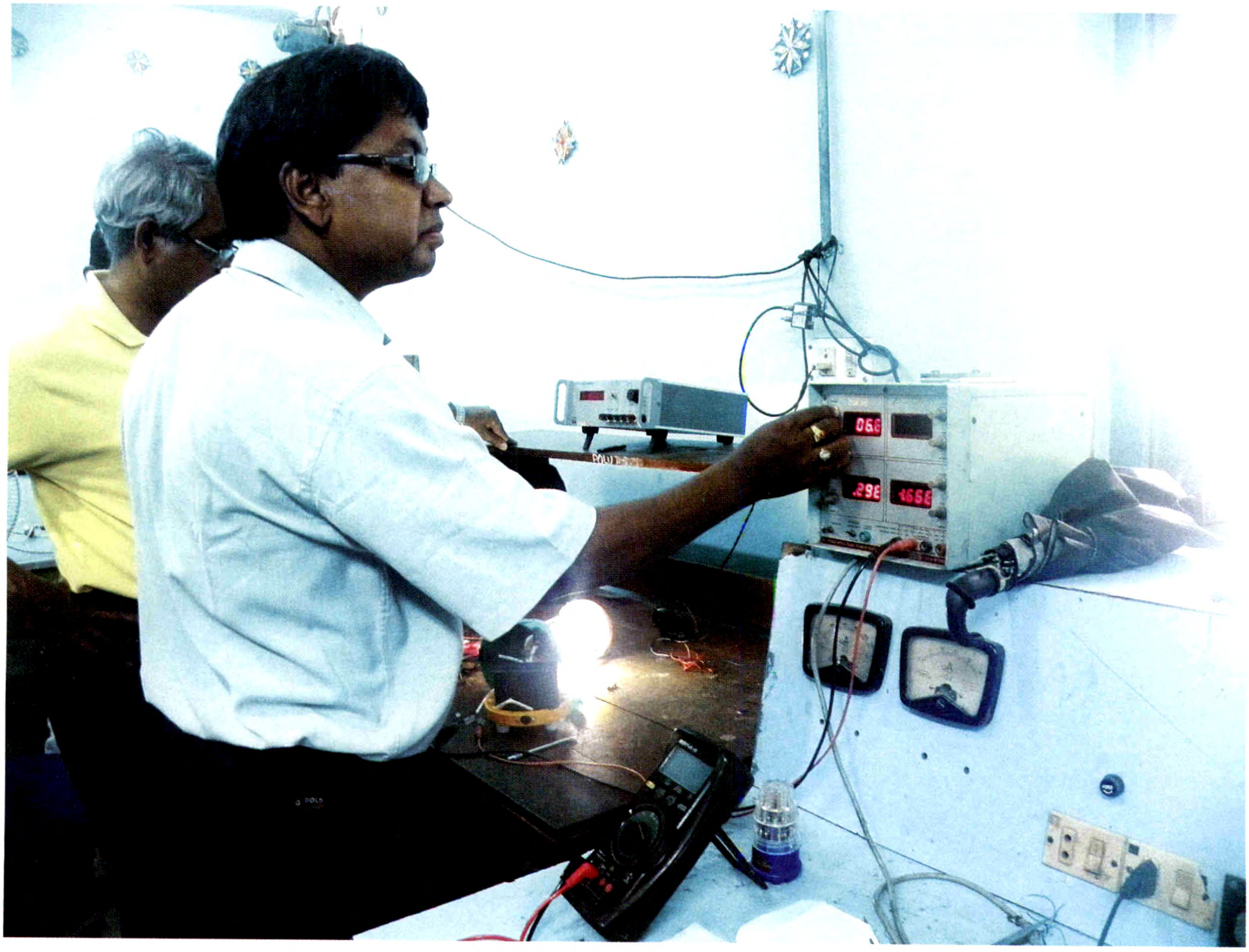
The author is Director, Ministry of New and Renewable Energy, New Delhi. Email: aktripathi@nic.in

Creating a Renewable Energy Skilled Workforce

Fellowship Programmes Under HRD Activities

The Ministry of New and Renewable Energy is taking various initiatives to meet the increasing demand of manpower in the renewable energy sector. Various training and fellowship programmes have been outlined and implemented to encourage study and research and enhance the potential for discovery and growth in this sector.

Dr P C Pant



The demand for skilled professionals in the new and renewable energy sector is set to make a quantum leap in the coming years. According to a study conducted by the Confederation of Indian Industries (CII) for the Ministry of New and Renewable Energy (MNRE) to analyse the employment potential (both direct and indirect) of this sector, the forecast is that the sector is expected to grow by 10 per cent, by the year 2020 and consequently the requirement of skilled professionals is estimated to be a whopping 10 lakh. To meet this colossal demand, the MNRE has begun taking proactive and futuristic steps in implementing a comprehensive human resource development programme to institutionalise renewable energy education and training by strengthening select educational institutions that are active in imparting renewable energy education at a formal level (Table-1). Various initiatives such as the award of Renewable Energy Chairs, monetary support for laboratory and library upgradation, fellowships, course development etc, have been incorporated besides supporting innovative and incubative activities.

National Renewable Energy Fellowship Programme

The programme was started by the Ministry in 1999 to attract young talent to work in the renewable energy sector and to eventually create a pool of qualified professionals. Under this scheme, the Ministry provides fellowships in three categories - Junior Research Fellow; Senior Research Fellow and M. Tech. The coordination for these fellowships were initially under the Centre for Energy Studies, IIT Delhi upto 2008 but was later transferred to TERI University which is handling it from 2009. However MNRE will independently coordinate the said fellowships from April 2012 onwards.

National Solar Science Fellowship Programme

The Ministry has instituted the prestigious National Solar Science Fellowship Programme wherein 10 fellowships will be awarded, to undertake research in the domain of solar energy. The awardees would be designated as National Solar Science Fellows and will work with premier educational or R&D institutions of the country. They will be entitled to a three year fellowship of Rs. 1 lakh per month besides a contingent grant of Rs. 5 lakh per annum and a research grant of Rs. 15 lakh per annum.

Hands on training of solar lanterns repair

Table 1: Summary of fellowships awarded under IIT Delhi (1999-2008)

Status	JRF	SRF	Ph.D Total	M. Tech	Total
Completed	11	41	52	149	200
Remaining	9	23	32	11	44
Total	20	64	84	160	244

Research area wise distribution of Ph.D Fellows (1999-2008)

Status	Solar Thermal	Solar (PV)	Bioenergy including biofuels	Others	Total
Completed	19	16	16	1	52
Remaining	7	7	4	14	32
Total	26	23	20	15	84

Ministry expanded National Renewable Energy Fellowship programme and increased number of fellowships in 2009-10

Course	Duration	Intake every year	Fellowship 1st Year	2nd Year	3rd Year (stabilised no. for subsequent years)
M.Tech	2 year	200	200	400	400
M.Sc	2 year	100	100	200	200
JRF	2 year	40	40	80	180*
SRF	3 year	40	40	80	120
RA/ PDF	3 year	20	20	40	60
Total		**400**	**400**	**800**	**960**

*This includes 100 integrated M.Sc students joining JRF.

Renewable Energy Chairs

MNRE has decided to set up Renewable Energy Chairs in the select educational institutions by providing a one time

Provisions have been made to give grant-in-aid support of upto Rs. 50 lakh to educational institutions to upgrade their laboratory and library facilities for courses offered in renewable energy.

Participants are being explained about components of SPV of systems

grant of Rs. 1.5 crore, to each of the chosen institutions. Such Chairs will act as the focal point for RE education and will be set up in upto 15 educational institutions. While most of the Chairs will focus on aspects of renewable energy in the broad framework of energy and environment, one or two Chairs may specifically be set-up in National Law Schools to understand renewable energy from a legal standpoint.

Support for upgrading laboratory and library

Provisions have been made to give a grant-in-aid support, of upto Rs. 50 lakh to specific educational institutions to help them upgrade their laboratory and library facilities, for courses being offered in renewable energy. This support will help in providing practical training during undergraduate and post-graduate courses.

Training of Technicians

With the increase in the demand for renewable energy plants and applications, many developers are faced with an acute shortage of trained manpower. To address this, the MNRE has adopted a two-pronged approach. Firstly, to upgrade the capacity of the Industrial Training Institutes (ITIs) to assimilate renewable energy training into their curricula and also to support short term training programmes in various organisations in collaboration with the local ITIs. A standard course material, developed in collaboration with the Directorate General of Employment and Training (DGET) in the areas of solar lighting, solar thermal and small hydro power, has been incorporated into the syllabus of the two year ITI course.

The Ministry has also been providing assistance of upto Rs.1.5 lakh, to State Nodal Agencies and other designated agencies to organise short-term, one-week training programmes. An MIS software has also been developed to prepare/update the database of trained manpower.

Syllabus Development

There is also a general consensus and an understanding that the Ministry, whenever required, may lend its support by contributing upto Rs. 5 lakh for the development of syllabus for a related course. It also intends to create a common platform wherein students, researchers and experts can share the facilities available in different institutions in the country. This can be achieved by networking of RE education and research institutions. The R&D and demonstration programme of RE technologies is more than 30 years old and more than 50 national institutions are involved with RE education and research. This information and the synergic integration of these institutions will be coordinated through a virtual network that will facilitate compilation of important data and circulate regular updates through a dedicated website.

Utilising High End Facilities

The government is supporting several projects creating high end infrastructure in the Solar Energy Centre, IITs, IISC and CSIR laboratories. To ensure that researchers across the country have access to these facilities, all national facilities and large equipment will be listed on the MNRE website and a synchronised mechanism to provide access will be created. A fund to support this initiative is proposed to be created in the 12th Plan. The government also proposes to extend the initial seed support including travel allowances and other benefits to help researchers.

These steps will go a long way in creating an enabling environment where studies in RE will be part of mainstream education and this will expectedly, meet the demand for qualified manpower in future. ❂

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Leading by Example

Rooftop Power Plant at MNRE

A pilot 20 kW Solar Photovoltaic (SPV) rooftop power plant installed on the MNRE Building in October 2010 has completed one year of continuous operations, supplementing grid supply in a real time office environment and has generated 24,739 kWh of electricity.

A K Varshney

The problem of power shortage is rampant in several towns and cities of our country resulting in a continuous increase in the demand for sufficient power generation and aggravating the dependency on non-renewable resources, such as diesel. An effective remedy to this problem is the use of modular SPV power plants of kW scale that can be set up on the rooftops of buildings, to supplement day time power needs besides reduction in diesel consumption as well as noise and air pollution. With a view to test and demonstrate the concept, the Ministry of New and Renewable Energy (MNRE) itself has set up a pilot SPV rooftop power plant of 20kW capacity on the terrace of its office building. This plant was installed and commissioned in October 2010 and has been in operation since then, supplementing the grid supply.

> **With a view to test and demonstrate the concept, MNRE decided to set up a pilot SPV rooftop power plant of 20kW capacity on the terrace of its office building.**

Plant description

The plant consists of 126 SPV modules each of 160W of CEL make and 6 SMA inverters, each of 3.8 kW rating. Its output is mixed with the grid supply to the building on distribution side; and at the emergency feeder point supply, from a centralised diesel generator (DG) set in CGO Complex which gets connected in the event of grid failure.

Table 1: Month-wise electricity generation and yield expectations

Month	Total yield (kW)	Yield expectations (kW)
January 11	1731.16	2131.11
February 11	2061.65	2259.23
March 11	2553.61	2809.20
April 11	2311.65	2890.44
May 11	2453.87	2999.81
June 11	1769.18	2871.69
July 11	2259.90	2971.68
August 11	1715.02	2965.44
September 11	2306.13	2752.95
October 11	2311.19	2540.46
November 11	1720.67	2099.87
December 11	1544.86	1956.12
Total	**24738.89**	**31248.00**

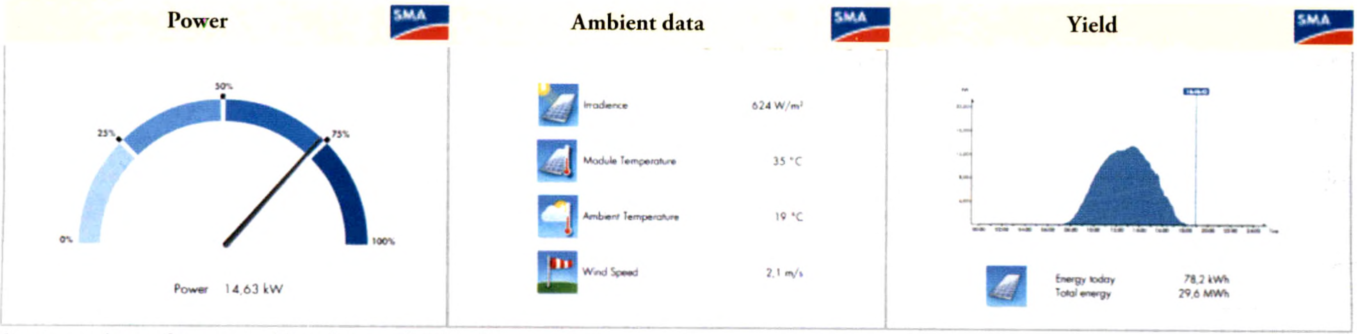
Source : MNRE

Solar panels set on MNRE building roof top at CGO Complex

Provisions have been made for a state-of-the-art on-line performance monitoring system, comprising of a sensor-box connected via a serial RS485 link to a web-box, from where the data is transferred to a PC and can be monitored from anywhere over the Internet.

Parameters monitored

The electricity generation from the plant has been recorded on a continuing basis over the last one year since December 2010. Various technical parameters are automatically sampled and stored at 15 minute intervals in a secured digital card. Specific parameters monitored include: (i) Energy related parameters - solar energy generated, electrical energy consumed (ii) Weather parameters - solar irradiance, module temperature, wind speed, ambient temperature (sensors for the last two added recently) and (iii) System parameters - array voltage, current, power, frequency, etc. Real time power generation and other data are continuously displayed on an LCD screen in the reception area of the building.



System analyses of power, ambient data, and yield of the power plant

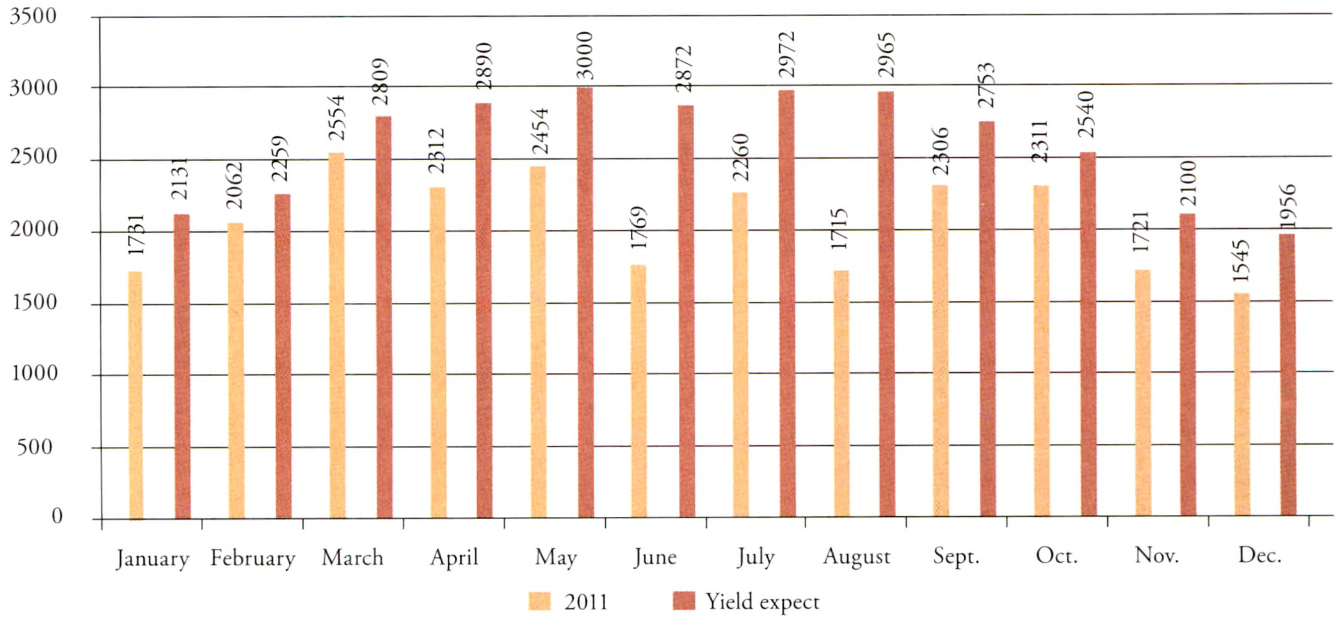
The snapshots above depict the power generation profile and instantaneous values of important parameters on a typical clear sunny day.

> **The actual total electricity generation during the year is 24739 units against expected yield of 31,248 units.**

Analysis of system's performance

The power plant has performed continuously without breakdown or any other problems during its first year of operation. Minor problems in data transfer link were encountered in the months of June and October 2011 but the same did not affect normal power generation from the plant. Table 1 and Fig 1 depict the actual electricity generation from the plant in each month, vis-à-vis yield expectations for the period Jan-Dec 2011, taking specific yield of 4.25 kW/ kW/day for Delhi.

Fig 1. Graph of actual electricity generation vis-à-vis expected yield



The actual total electricity generation during the year is 24739 units against expected yield of 31,248 units. The same corresponds to 79.17 per cent of the expected yield for Delhi at 4.25 kW/kW/day. Factors contributing to the shortfall include mainly (i) partial shadowing of few modules near boundary walls of the terrace during winter months (ii) dust cover on modules (being cleaned weekly) and (ii) periods of failure of grid/ diesel power supply to the building especially in the summer months during which the plant could not generate or transfer power (avoidable through some design modification with extra investment). The latter has been significant during the months of June and August and is being analysed further.

Conclusion

The plant has operated satisfactorily for one year and two months now and its annual yield is close to 80 per cent of the expected yield, which is reasonably good. The plant's performance is being monitored which will help provide valuable insights and inputs in the design and development of similar other plants in future to be used for different applications and situations, and also for seeking guidance in decisions related to policy and investment of SPV rooftops. Prima-facie, at current price levels, such plants can be a viable proposition for both industrial and commercial entities which are heavily dependent on DG sets for meeting their day time power requirements. ✪

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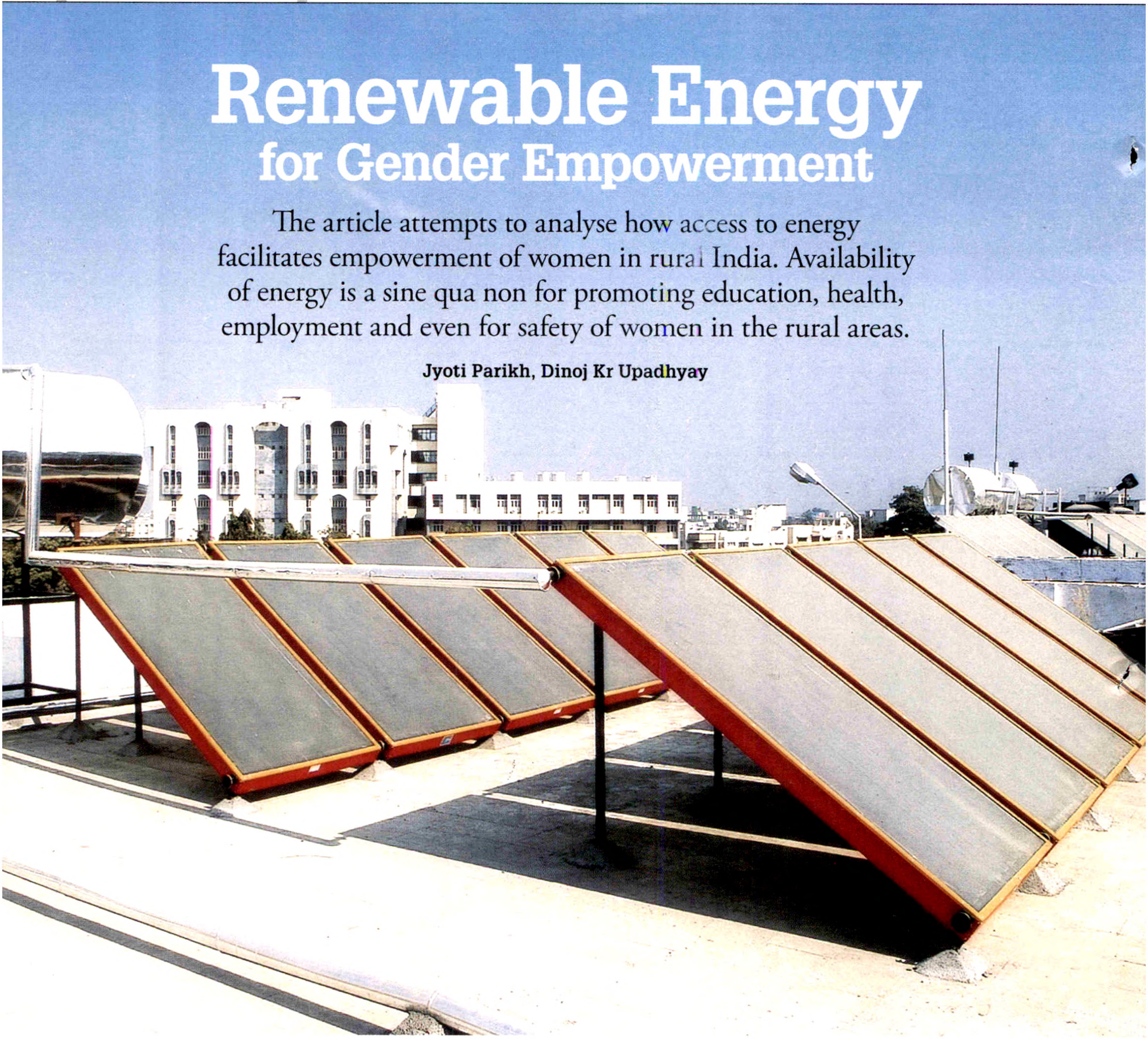
Renewable Energy for Gender Empowerment

The article attempts to analyse how access to energy facilitates empowerment of women in rural India. Availability of energy is a sine qua non for promoting education, health, employment and even for safety of women in the rural areas.

Jyoti Parikh, Dinoj Kr Upadhyay



Energising gender empowerment is a central and recurring theme with policy makers subscribing to the different paradigms of developmental philosophies. It is well recognised that uninterrupted and adequate supply of energy at an affordable price is indispensable for economic growth and social development as well as for the empowerment of the weaker sections of society, particularly women. Due to their social status and specific role in household management, the implications of unavailability of clean and renewable energy for women are severe. Thus, to provide clean and modern energy resources to women and give them a greater role in decision-making and management of these resources and implementation of energy projects is deemed to be a crucial element of the current gender empowerment discourse. At present, a majority of Indian households (approximately 70 per cent according to Census of India 2001) are dependent on traditional forms of energy like wood fuel, crop residues, animal dung, etc for cooking. Women are the key agents of household management and are usually involved with the gathering of these energy resources for cooking and other household activities.

Indeed for their personal development too, access to modern energy appears to be quite critical.

Status of Renewable Sources of Energy in India

Briefly speaking, India faces formidable challenges in bridging the energy gap and coping with the ballooning energy demands. It has been estimated that over 625 million people do not have access to modern and clean energy. According to World Energy Outlook 2011, International Energy Agency, 289 million people (25 per cent of total population) do not have access to electricity and around 836 million people (72 per cent of total population) still rely on traditional use of biomass for cooking. Also the projected demand for energy is set to increase rapidly and this poses a daunting challenge to cope with. As per the forecast of the Indian Renewable Energy Status Report 2010, National Renewable Energy Laboratory (NREL), India's oil demands are set to rise by 41 per cent in 2015 and by 150 per cent by 2030 and to meet the electricity demand of its population, India needs to double its installed capacity to over 300 GW by 2017. In such a precarious scenario, the country has every reason to vigorously endeavour to explore, promote production and uses of new and renewable energy sources. Fortunately the country has been endowed with an immense potential for production of renewable energy. At the policy level, the government has already recognised that harnessing local renewable resources is critical for environmentally compatible, faster economic growth and to meet energy demands at the local level. The Ministry of New and Renewable Energy's (MNRE) Report (June 2010) states that India has over 17.5 GW of installed renewable energy capacity, which is approximately 10 per cent of India's total installed capacity. Wind represents 11.8 GW, while small hydro represents 2.8 GW, and the majority of the remainder is from biomass installations. Also PV installations have reached 15 MW of cumulative capacity installation for both on and off-grid applications (Indian Renewable Energy Status Report 2010). However, from the gender perspective, we need to understand as to how many of these projects can actually relieve women from the burden of gathering fuel. They can definitely benefit from the range of services that renewable energy products provide such as cooking, lighting, drying, battery charging, street lighting and so on.

P 35,430

> **Availability of adequate energy will mean easy access to water and irrigation, enhanced food security and income and pollution free fuel, leading to prevention of heart and lung diseases.**

Women with solar powered lamps

Renewable Energy: Facilitating Gender Empowerment

To effectively interlink renewable energy with empowerment of women, initiatives need to be taken at two levels. Firstly, the use of renewable sources of energy and renewable energy based appliances should be promoted in their daily lives; secondly, women should be encouraged to participate in the management and implementation of energy projects at the community and household levels. Renewable energy powered appliances can facilitate basic requirements such as lighting, cooking, cleaning, water lifting etc. Innovative products like improved *chulhas* (cook-stoves), biogas, solar cookers, solar lanterns, solar dryers, eco-cookers and multiple uses of Jatropha, will go a long way in empowering the womenfolk. Lighting is essential for education in India in general and rural areas in particular. Solar dryers are a boon in remote hilly areas, enabling drying of vegetables, fruits and other post-harvest operations. Many women's groups are using such dryers on a commercial scale. Biofuel plantations could be successfully used to improve the livelihoods of poor rural women on a sustainable basis and to rehabilitate degraded lands and improve the environment.

Availability of adequate energy will help women gain easy access to water and irrigation, enhance food security through better crop productivity, income from agro-food processing, pollution free fuel and prevention of heart and lung diseases. It will generate extra income through agri-waste processing and storage, diversification of crop

> **The WHO report, Fuel for Life: Household Energy and Health 2002, says that indoor pollution kills around 1.5 million people every year, mostly young children and their mothers.**

production or higher yields via modern farming tools/techniques, ability to process materials locally, and their storage, diversification of the off-farm activities like dairy products, other small scale businesses. Energy will also play a major role in helping women mould their personalities and spend more time on self development through training and education, leisure, entertainment, etc. Also they can spend quality time with their children. Street lighting will improve women safety. Health-wise too, it will lead to the reduction in various and heart and lung diseases that occur due to prolonged exposure to smoke generated by wood and biomass. The WHO Report, Fuel for Life: Household Energy and Health 2002, says that indoor pollution kills around 1.5 million people every year, mostly young children and their mothers. A survey conducted by Integrated Research and Action for Development (IRADe) in three states of north India and one state of South India shows that respiratory symptoms are prevalent among 24 million adults of which 17 million have serious symptoms. Five per cent of adults suffer from bronchial asthma, 16 per cent from bronchitis, 8.2 per cent from pulmonary TB and 7 per cent from chest infection. Promoting the uses of renewable energy services and modern energy appliances, will considerably reduce these besides providing better access to and storage of medicines. Power is the prerequisite for providing medical services in the night and the working of many medical devices and improve the functioning of health clinics and hospitals.

Involvement in management of renewable energy resources implies the inclusion of women in every aspect of organisational set-up of renewable energy maintenance, resource planning, marketing, and decision making. They can participate in village energy schemes as consumers (enterprise), franchisee (tasks like billing, maintaining accounts, and revenue collection). Women's representation should be made mandatory in the decision making process. At the local or community level, women should be part of the installation, operations and management and should be provided with opportunities to enhance their capacity in management and financial issues. When sustainable operations of different renewable energy technology units get disrupted due to the inexperience in operating these, it can be strengthened by appropriate interventions focussing on raising the capacity of men and women in handling and maintaining the equipment.

Concluding Remarks

To sum up, renewable energy bears a significant impact not only upon the global economy and environment but also with social development and gender empowerment. However, certain issues must be looked into at the policy and implementation levels.

- At the stage of project decision, there should be identification and clear articulation of gender goals in the preparation of energy programmes using explicit and measurable variables and indicators. It is crucial to ensure that there is gender sensitivity in planning and management of the programmes.
- Investment is a crucial aspect of energy development and sufficient allocation with accountability to gender goals is needed.
- At the implementation level, appropriate strategies and plans should be developed. Financial and technical support to self help groups, women's groups, etc. in promoting use of energy appliances such as solar lanterns, eco-cookers etc. should be sought with suitable business models that would save fuel and promote the uses of renewable energy.
- Monitoring and evaluation using strategic gender indicators is essential to strengthen the accountability of various ministries, in terms of their performance on gender and energy.
- Effective inter-ministerial coordination is imperative in specific areas such as accessibility, availability and utilisation of renewable and other environment friendly energy sources.
- This is also true with particular reference to gender budgeting at the central level which needs to be facilitated effectively. The MNRE's Gender Budgeting Cell (GBC) should collaborate with GBCs in other ministries and provide the necessary support to incorporate energy in their gender budget programmes. To ensure effective utilisation of gender budgets within ministries, appropriate capacity development initiatives should be designed and supported. ❂

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Climate Change and Renewable Energy

IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, 2011

As emission rates substantially exceed natural removal rates, concentrations of CO_2 will continue to increase, which will raise global mean temperature. In the absence of additional climate policies, the Intergovernmental Panel on Climate Change (IPCC) projected in 2007 that global average temperature will rise over this century by about 1.1°C to 6.4°C.

Greenhouse gas (GHG) emissions associated with the provision of energy services are a major cause of climate change. The IPCC 4th Assessment Report 2007, concluded that "Most of the observed increase in global average temperature since the mid 20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." Concentrations of CO_2 have continued to grow since the Report to about 390 ppm CO_2 or 39 per cent above pre industrial levels by the end of 2010. The global average temperature has increased by 0.76°C (0.57°C to 0.95°C) between 1850 to 1899 and 2001 to 2005 and the warming trend has increased significantly over the last 50 years. While the current IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation focuses on the energy sector, forest clearing and burning and land use change and the release of non CO_2 gases from industry, commerce and agriculture also significantly contribute to global warming.

An extensive review of long-term scenarios revealed that economic growth is expected to lead to a significant increase in gross domestic product (GDP) during the 21st century associated with a corresponding increase in the demand for energy services. Also carbon intensity (the amount of CO_2 emissions per unit of primary energy) is, with few exceptions, expected to decrease as well. In addition to an investigation of potentially irreversible abrupt changes in the climate system, the IPCC assessed the adverse impacts of such climate change (and the associated sea level rise and ocean acidification) on

> **Most of the observed increase in global average temperature since the mid 20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.**

water supply, ecosystems, food security, human health and coastal settlements. The Cancun Agreements (2010) call for limiting global average temperature rise, to not more than 2°C above pre-industrial values and agreed to consider a goal of 1.5°C. GHG concentrations would need to be in the range of 445 to 490 ppm CO_2 eq in order to be confident of achieving an equilibrium temperature increase of only 2°C to 2.4°C. This in turn implies that global emissions of CO_2 will need to decrease by 50 to 85 per cent below 2000 levels by 2050 and begin to decrease (rather than continuing current increase) no later than 2015.

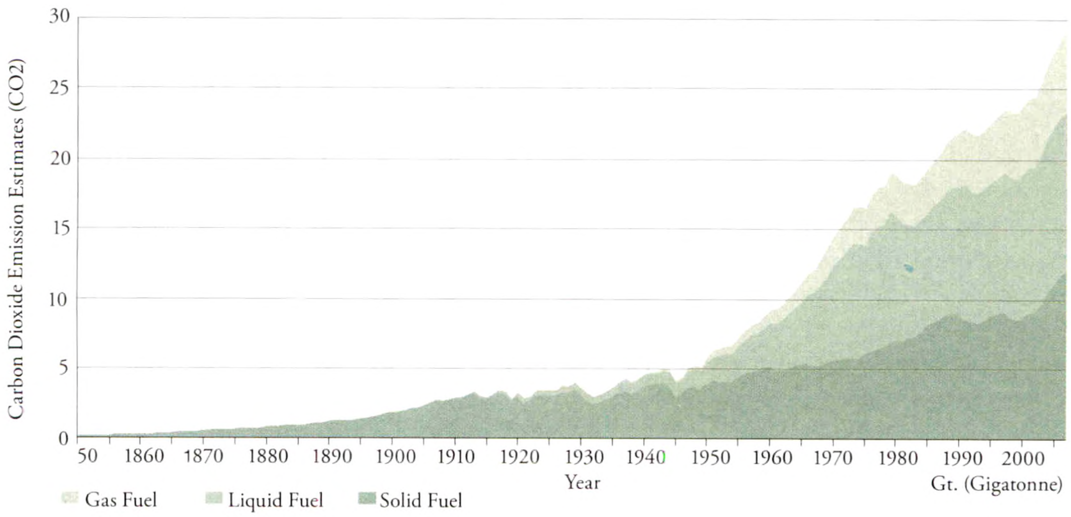
Drivers of carbon dioxide emissions

Since about 1850, global use of fossil fuels (coal, oil and gas) has increased to dominate energy supply (Fig. 1), both replacing many traditional uses of bioenergy and providing new services. The rapid rise in fossil fuel combustion (including gas flaring) has produced a corresponding rapid growth in CO_2 emissions. The amount of carbon in fossil fuel reserves and resources (unconventional oil and gas resources as well as abundant coal) not yet burned has the potential to add quantities of CO_2 to the atmosphere - if burned over coming centuries - that would exceed the range of any of the scenarios considered.

Renewable energy to mitigate climate change

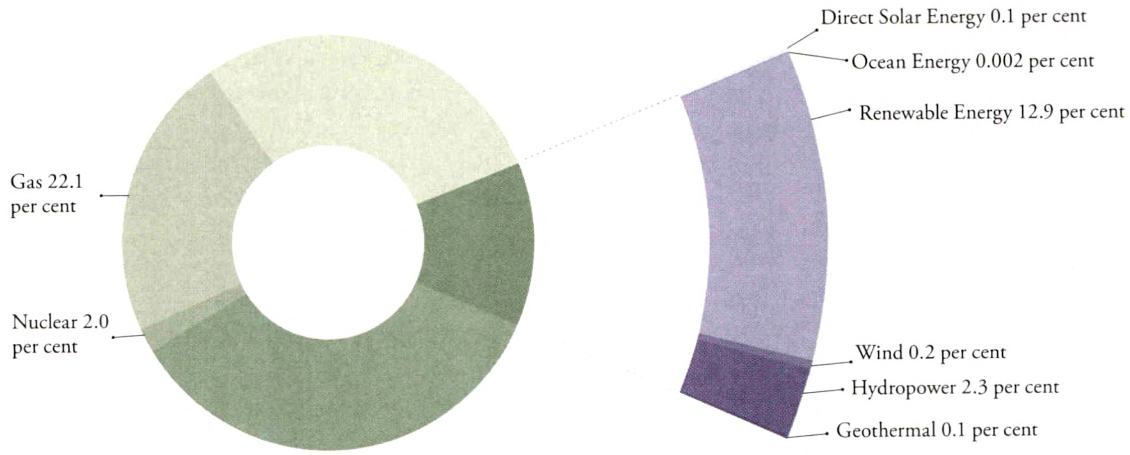
Renewable energy (RE) supply sources are effective in lowering CO_2 emissions because they have low carbon intensity with emissions per unit of energy output typically 1 to 10 per cent that of fossil fuels. On a global basis, it is estimated that RE accounted for 12.9 per cent of the total 492 exajoule (1 EJ = 1018 joule) of primary energy supply in 2008. The largest RE contributor was biomass (10.2 per cent), with the majority (roughly 60 per cent) of the biomass fuel used in traditional cooking and heating applications in developing countries, but with rapidly increasing use of modern biomass as well. Hydropower represented 2.3 per cent, whereas other RE sources accounted for 0.4 per cent. In 2008, RE contributed approximately 19 per cent of global electricity supply (16 per cent hydropower, 3 per cent other RE). Global electricity production in 2008 was 20,181 TWh (or 72.65 EJ). Deployment of RE has been increasing rapidly in recent years. Under most conditions, increasing the share of RE in the energy mix will require policies to stimulate changes in the energy system. Government policy, the declining cost of many RE technologies, changes in the prices of fossil fuels and other factors have supported the continuing increase in the use of RE. While RE is still relatively small, its growth has accelerated in recent years. In 2009, despite global financial challenges, RE capacity continued to grow rapidly, including wind power (32

Fig 1. Global CO_2 emissions from fossil fuel burning, 1850 to 2007. Gas fuel includes flaring of natural gas. All emission estimates are expressed in Gt CO_2. Data Source: (Boden and Marland, 2010)



per cent added), hydropower (3 per cent added), grid-connected photovoltaics (53 per cent added), geothermal power (4 per cent added) and solar hot water/heating (21 per cent added) (REN21 2010). Biofuels accounted for 2 per cent of global road transport fuel demand in 2008 and nearly 3 per cent in 2009. The annual production of ethanol increased to 1.6 EJ (76 billion litres) by the end of 2009 and biodiesel production increased to 0.6 EJ (17 billion litres). Of the approximate 300 gigawatts (GW) of new electricity generating capacity added globally over the two year period from 2008 to 2009, 140 GW came from RE additions. Collectively, by the end of 2009 developing countries hosted 53 per cent of global RE power generation capacity (including all sizes of hydropower), with China adding more capacity than any other country in 2009. The USA and Brazil accounted for 54 and 35 per cent of global bioethanol production in 2009, respectively, while China led in the use of solar hot water. At the end of 2009, the use of RE in hot water/heating markets included modern biomass (270 GWth), solar (180 GWth) and geothermal (60 GWth). The use of RE (excluding traditional biomass) in meeting rural energy needs is also increasing, including small hydropower stations, various modern bioenergy options and household or village PV, wind or hybrid systems that combine multiple technologies (Fig 2).

Fig 2. Shares of energy sources in total global primary energy supply in 2008 (492 EJ).
Data source: IEA (2010a).



Most RE technologies have low specific emissions of CO2 into the atmosphere as compared to fossil fuels, which makes them useful tools for addressing climate change. For a RE resource to be sustainable, it must be inexhaustible and must not damage the delivery of environmental goods and services including the climate system. For example, to be sustainable, biofuel production should not increase net CO2 emissions, should not adversely affect food security, or require excessive use of water and chemicals or threaten biodiversity. To be sustainable, energy must also be economically affordable over the long term; it must meet societal needs and be compatible with social norms now and in the future. Indeed, as use of RE technologies accelerates, a balance will have to be struck among the several dimensions of sustainable development. It is important to assess the entire lifecycle of each energy source to ensure that all dimensions of sustainability are met.

> **Most RE technologies have low specific emissions of CO_2 into the atmosphere as compared to fossil fuels, which makes them useful tools for addressing climate change.**

Options for mitigation

There are multiple means for lowering GHG emissions from the energy system while still providing energy services. Many options and combinations are possible for reducing emissions. The Assessment Report 2007, identified a number of ways to lower heat trapping emissions from energy sources while still providing energy services. They include:

- Improve supply side efficiency of energy conversion, transmission and distribution including combined heat and power;
- Improve demand side efficiency in the respective sectors and applications (e.g., buildings, industrial and agricultural processes, transportation, heating, cooling, lighting etc.);

This Report of the IPCC focuses on substitution of fossil fuels with low carbon RE to reduce GHGs, and examines the competition between RE and other options to address global climate change.

Wind turbines

- Shift from high GHG energy carriers such as coal and oil to lower GHG energy carriers such as natural gas, nuclear fuels and RE sources;
- Utilise carbon capture and storage (CCS) to prevent post combustion or industrial process CO_2 from entering the atmosphere. CCS has the potential for removing CO_2 from the atmosphere when biomass is burned; and
- Change behaviour to better manage energy use or to use fewer carbon and energy intensive goods and services.

Two additional means of reducing GHGs include enhancing the capacity of forests, soils and grassland sinks to absorb CO_2 from the atmosphere and reducing the release of black carbon aerosols and particulates from diesel engines, biomass fuels and from the burning of agricultural fields. Additional reductions in non CO_2 heat trapping GHGs (CH_4, N_2O, hydrofluorocarbons, sulphur hexafluoride) can also reduce global warming.

Geoengineering solutions have been proposed to address other aspects of climate change, including altering the heat balance of the Earth by increasing surface albedo (reflectivity), or by reflecting incoming solar radiation with high altitude mirrors or with atmospheric aerosols. Enhanced CO_2 absorption from the atmosphere through ocean fertilisation with iron has also been proposed and tested. A comprehensive evaluation of any portfolio of mitigation options would involve an evaluation of their respective mitigation potential as well as all associated risks, costs and their contribution to sustainable development.

This Report of the IPCC focuses on substitution of fossil fuels with low carbon RE to reduce GHGs, and examines the competition between RE and other options to address global climate change. Setting a climate protection goal in terms of the admissible change in global mean temperature broadly defines (depending on the assumed climate sensitivity) a corresponding atmospheric CO_2 concentration limit and an associated carbon budget over the long term. This budget, in turn, can be broadly translated into a time dependent emission trajectory that serves as an upper bound or (if the remaining time flexibility is taken into account) in an associated corridor of admissible emissions. Subtracting any expected CO_2 emissions from land use change and land cover change constrains the admissible CO_2 emissions that could be realised by freely emitting carbon fuels (i.e., coal, oil, and gas burned without applying carbon capture technologies). The corresponding fossil fuel supply is part of the total primary energy supply. The remainder of the total primary energy supply (TPES) is provided by zero or lowcarbon energy technologies, such as RE, nuclear or the combustion of fossil fuels combined with carbon capture and storage (CCS). Whereas the admissible amount of freely emitting fossil fuels is mainly fixed by the climate protection goal, the complementary contribution of zero or low carbon energies to the primary energy supply is influenced by the 'scale' of the requested energy services and the overall efficiency with which these services can be provided.

Technical improvements and structural changes are expected to result in considerably lower emissions than otherwise would be projected. As many low cost options to improve the overall energy efficiency are already part of the non intervention scenarios the additional opportunities to decrease energy intensity in order to mitigate climate change are limited. In order to achieve ambitious climate protection goals, for example, stabilisation below the aforementioned 2°C global mean temperature change, energy efficiency improvements alone do not suffice. In addition, low carbon technologies become imperative. There are large uncertainties in projections, including economic and population growth, development and deployment of higher efficiency technologies, the ability of RE technologies to overcome initial cost barriers, preferences, environmental considerations and other barriers ✪

Excerpts from IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1075 pp, 2011.

From Darkness to Light

Renewable Energy Impacting Development in Chhattisgarh

A study of how the CREDA has launched a green project in Chhattisgarh to electrify remote naxal ridden villages using solar photovoltaic technology.

S K Shukla

The Chattisgarh Renewable Energy Development Agency (CREDA) was constituted in the year 2001 coinciding with the year of inception of the new state of 'Chhattisgarh'. The mandate was clear: harness the resources available and develop green power projects to benefit the people. However, as clear as the mandate was, the situation at hand seemed beyond help. More than 2000 remote villages, tribal hostels, institutions and buildings were struggling without electricity in this naxal ridden area. With no kerosene available, people used *'mashals'* (fire-lit torches made of wood), for light. Roads full of land mines and continuous naxal threats, made it difficult for the government to begin welfare for its people. However, the CREDA overcame the odds to bring electricity to these villages using Solar Photovoltaic (SPV) Technology. Now, more than 1400 remote villages

80 kW SPV plant at CREDA and CSERC building, Raipur

> **The State is targeting to electrify the remaining 654 villages through SPV, in the next two years, making the Chhattisgarh 100 per cent electrified.**

62 kW SPV plant at Banyan Tree residential colony, Raipur

and 1200 tribal hostels are solar electrified. Solar power plants with capacities ranging from 3 to 25 kW have been installed in these villages. A network of trained operators and solar technicians has also been developed for the upkeep and maintenance, generating employment in the renewable energy (RE) sector, for more than 4000 hitherto disadvantaged tribals.

The project

The purpose of the Remote Village Electrification (RVE) project is to electrify more than 1447 remote villages/ hamlets, 1200 tribal hostels, 178 police stations, 47 base camps of paramilitary forces (in naxal ridden areas), using renewable energy sources and to ensure their maintenance through a strong network of service providers. This programme, designed and implemented by the CREDA is multi-faceted and integrates the dissemination of RE technologies with income-generating activities and local development programmes to benefit the local economy. However, due to technical, administrative and economical hurdles, this tedious task was not possible using conventional means of hydel and thermal power generation and their distribution through the national grid. Significantly therefore, the roles of off-grid alternative/renewable energy (AE/RE), have gained acceptance as workable options. The idea is to interact with the local community and get them involved and to assist them until the task is completed, making them self-sufficient.

Objective of the project

The essential objective of this project is to emancipate the people of the region and rid themselves of their backwardness. A wave of change will come about when something as simple yet revolutionary as electricity reaches these hitherto dark villages. Hence to begin with, the CREDA obtained a list of unelectrified villages, from the Chhattisgarh State Electricity Board. Priority was given to villages where grid electrification was not possible. The task of supplying electricity began in 2002. Initially, stand alone solar home lighting systems were installed in about 90 villages through a 100 per cent subsidy programme. The system comprised of PV modules, cables, an inverter, a battery and CFLs but half the panels got stolen within a year. A survey in 2004 showed that of the 617 solar modules installed in tribal hostels, ashrams and primary health centres, nearly 200 were stolen. This then prompted the need to explore alternative methods and led to the idea of using SPV micro-grids. These grids were installed in large villages with higher concentration whereas stand alone home lighting systems were placed in villages that had scattered houses. The first micro-grid came up in 2003 and by March 2011, the CREDA had already electrified 1,447 villages using SPV. About 1000 of these have micro grids with a total installed capacity of 3.35 MW, providing electricity to over 95,000 households. The State is targeting to electrify the remaining 654 villages through SPV in the next two years thus making the State 100 per cent electrified. More than 1200 hostels have been electrified using SPV and there are plans to electrify the remaining 800 hostels. All the systems installed so far are 100 per cent subsidised using Central and state government funds.

Working of the project

The success of the project depends on the upkeep and maintenance of the grids. To ensure this, the CREDA follows a three-tier system. At the first tier, operators are chosen from each solar-powered village to clean the solar modules daily and repair them if required. The CREDA charges a monthly fee of Rs. 5 from each house, towards this. At the second tier, CREDA enrols an operation and maintenance contractor, who appoints a cluster technician for every 10-15 villages, for maintaining batteries, inverters and fixing other technical faults. The service provider directly receives a payment of Rs. 45 per household per month from the State Government. For the tribal hostels and other solar installations too, a network of trained technicians who monitor, maintain and submit reports on a regular basis has been developed.

The third tier is managed by the CREDA itself and it monitors all installations through monthly reports and replaces equipment in case of major breakdowns. Uninterrupted scheduled power supply has not only minimised cases of stealing or selling of solar panels, but has fuelled the commercial demand for these systems in the region. The structure of maintenance is such that the SPV system provides continuous power. Technicians have enough stock of spares and can freely replace defunct lamps and equipment, without awaiting formal permission.

Handling emergencies has also been given due consideration. Monsoons in the State often make the roads inaccessible and in the event of a power failure, a spare inverter has been placed in every cluster. Also the head office stores a spare inverter in the eventuality of the back-up inverter failing.

The CREDA regularly trains its technicians, updating them on maintenance issues and an annual budget of Rs. 10 lakh is reserved for training activities. Additionally 60 supervisors are also engaged to undertake any kind of repair work. The CREDA has trained more than 500 workers for installations and maintenance of SPV systems. There are 20 service centres spread across the State that report any defects in the functioning of the systems.

Impact assessment study

The programme has positively impacted almost all 18 districts of Chhattisgarh with more than 1 lakh, mostly tribal families being covered. Internationally too, the CREDA model has gained popularity, with countries like Kenya, Nigeria and Bangladesh, inviting the organisation to help implement the same in their country. The CREDA's model has also been accredited by Indu Shekhar Singh National Level Monitor, MNRE, GOI - a Patna based agency, in its report. The following is a summary of the said report.

- The project area has been visited and assessed by experts, social scientists and organisations from more than 25 countries. A key element of this programme is the self-reliance it has given to the villagers who maintain and run the system independently, without direct government/political assistance. The CREDA's role is limited to the installation, giving technical guidance and monitoring their functioning.
- Evolution in the social fabric is evident from subtle changes like the advent of television. Education too has gained importance with demands for schools imparting higher education, thanks to the children being able to study during the night. Further, there is no noise or air pollution from these systems.

> **The programme has positively impacted almost all 18 districts of Chhattisgarh with more than 1 lakh, mostly tribal families being covered.**

2 MW Solar Power Plant at Kharora, Raipur

- Although the State is meeting its energy needs, the question that looms large is whether this can be attained in an environmentally sustainable manner. The fact that environmentally safer systems are not promoted as lucrative options is a major dampener. However energy can become an instrument for sustainable development if there is a strong partnership between the government, civil society, private and public sector. The CREDA is committed to working on sustainable energy options.
- The productivity level of agricultural activities and the involvement of women in economic activities along with household work is a clear sign of its sociological impact. Environmentally too, the SPV system scores higher than its conventional counterparts making a strong case in its favour despite its current unfavourable position vis-a-vis its direct cost of production.

Future Action Plan

The CREDA targets at providing all solar electrified villages with a 24 hour electricity supply and desires that every village and household of the State must have electricity. More than 12 MW capacity roof top solar power plants numbering about 3000 have been installed and the goal is that no State building using more than 10 kW should depend upon conventional power. ✪

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Small Flames Igniting
Big Transformation

Shakti Surabhi - a bio-methanation plant comes as a blessing to villages near Tiruchi district of Tamil Nadu.

V Ramakrishnan

Sarada Priya, a house wife living in a rented house in a village near Tiruchi district of Tamil Nadu was disappointed. Her house-owner had rejected her request to have a small biogas plant installed in her backyard. This was not meant to be a regular biogas plant that would run on cattle waste instead it would run on domestic organic waste. "The gas may leak…and that will be dangerous", he said, "Further there will be a foul smell and there are other residents here… what if that creates additional pollution?" Sarada Priya had been approached by a voluntary organisation, Vivekananda Kendra Natural Resources Development Project, popularly known as VK-NARDEP, from Kanyakumari who had got her interested in the idea of a backyard energy source for her kitchen using her own kitchen waste. Sarada Priya persisted and finally the house-owner relented. "OK" he said, "but only a trial and in case of any problem - the very next second the contraption goes". However the plant - called Shakti Surabhi, proved to be an efficacious system than a mere exotic 'contraption'. In Sarada Priya's own words, "Slowly people started appreciating the worth of the plant. While for my own family there was economy of fuel, the neighbours too began to see the positive changes in the surroundings. Our usual practice was to dump domestic organic waste in the drainage. This had resulted in the breeding of rats which were a major menace. Further the drainage channels would get blocked and would often emanate a foul odour."

The Shakti Surabhi had provided them with a simple and effective solution for recycling waste, ridding them of the problems associated with waste disposal. Soon the hitherto reluctant house-owner was visibly happy with the technology.

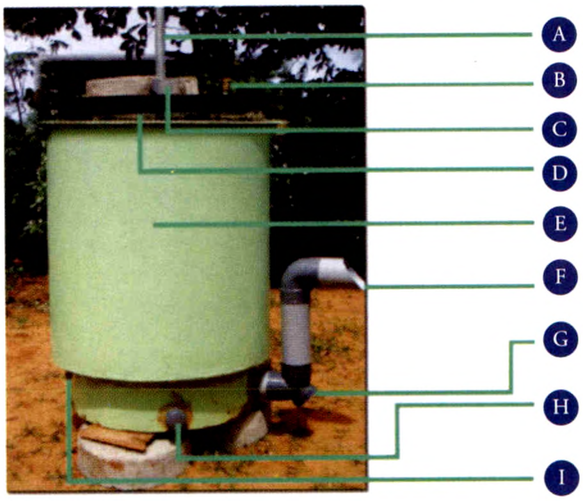
The logical question that arises here is how a relatively simple technology like this can meet India's burgeoning energy needs and bridge the gap in this huge urban-rural energy divide. While urban India is utilising largely subsidised commercial energy, rural India is essentially dependent on dwindling sources of non-commercial primary energy, both of which are non-sustainable in the long run. Another related and pressing issue is the problem of pollution from domestic organic waste, the disposal of which poses a serious problem in many rural Indian households as well as in high density urban environments.

To tackle these twin problems, the Vivekananda Kendra offers the Shakti Surabhi as a sustainable solution. The Natural Resources Development Project known as VK-NARDEP is an integral part of the Vivekananda Kendra and has been working for more than 25 years in the field of sustainable development. Its work in renewable energy has even won the organisation, the prestigeous international Ashden Award. The VK-NARDEP's Shakti Surabhi is technically a bio-methanation plant working on a process by which methane generating microbes convert organic waste into methane gas. The plant as designed by VK-NARDEP consists of a collector drum into which organic waste from households is fed and then worked upon by bacteria to produce methane gas which is supplied back to the kitchen through a pipeline. The plant in addition also produces slurry from the left over substrate that works as an excellent fertiliser.

The Shakti Surabhi as a decentralised backyard energy source has been successful in transforming the energy scenario of households where they are installed. A one cubic metre capacity plant, which is suitable for an average household needs just five kilograms of organic waste to be fed into it every day for it to generate approximately two to three hours of gas production. An important aspect of the plant is that it has been designed to work effectively even with reduced levels of input. Even on a day when the amount of organic waste generated is less than required the plant will still be able to produce adequate gas. The compact design of the plant makes it convenient for use even in cities. These usually come in black so as to increase their solar thermal efficiency. They are portable, can be easily moved and are available in capacities ranging from 0.5 to 6 cubic metre. Fixed model plants are also available. These are economical and more suited for rural areas.

The Shakti Surabhi had provided them with a simple and effective solution for recycling waste, ridding them of the problems associated with waste disposal.

Fig 1. A labelled diagram of a bio-methanation plant

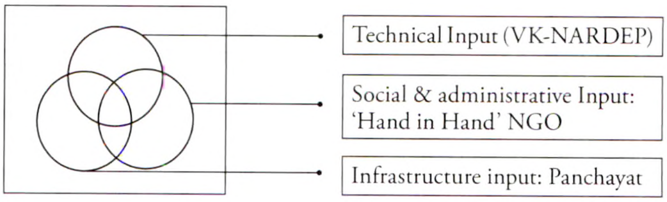


A	Guide Pipe	E	Digestor
B	Gas Outlet	F	Outlet Pipe
C	Inlet Pipe	G	Emergency Slurry Drain
D	Gas Holder	H	Substrate Drain
		I	Water Drain

There are many more innovative features embedded in this plant that make its functioning efficient and easily manageable (Fig 1). For example (i) the input pipe through which the waste is fed is long and extends into the digestor of the plant. This digestor is the place where the bacteria produce the gas. (ii) The gas collector drum is supported by a guide pipe which allows both rotational and vertical movement of the gas collector drum. There are supporting rods inside and these help in breaking the scum during such rotatory motions. (iii) The slurry output is U-shaped which prevents the short-circuiting of the input, which means that the slurry is released only after all the input has been digested and all the gas is extracted. (iv)There is also a water jacket around the plant which prevents any leakage of gas and conceals the input waste, giving the plant a cleaner look. Further, it gives buoyancy to the gas collector drum and with the counter-weights on the drum it provides enough pressure for the gas collected in the drum to go straight to the stove or cooking device.

> **In the tourist town of Mamallapuram a large plant produces electricity from organic waste. Though the town has just 400 households, it generates kitchen waste from various hotels and restaurants.**

Mamallapuram Model


Technical Input (VK-NARDEP)
Social & administrative Input: 'Hand in Hand' NGO
Infrastructure input: Panchayat

The Shakti Surabhi's technology is beneficial not just to individual households but also large institutions with hostels and community kitchen halls. "The bio-methanation plant that has been installed by VK-NARDEP has really come as a blessing for us," says the incharge of Mahatma Gandhi Education and Charitable Trust at Surandai village in Thirunelveli district. Turning philosophical he states, "What was once considered waste, is today seen as having wealth potential...it has changed our perception... Now we feel satisfied from within that we are utilising the waste and converting it to energy. This makes us proud of our contribution to the welfare of society."

The plant design has been approved by the Ministry of New and Renewable Energy (MNRE) and is being manufactured in LLDP (plastic) which is more durable. Larger plants are also being constructed. In the tourist town of Mamallapuram near Chennai, a community-operated large Shakti Surabhi plant produces electricity from organic waste. Though the town is small with a population of just 12,000 in about 400 households, it generates a huge volume of kitchen waste from various hotels and restaurants. The lack of a proper waste management system, could lead to manifold health problems and affect tourism, the mainstay of Mamallapuram. Tackling this needed, not just technical inputs but the creation of tangible and intangible social infrastructure.

A resident of Tiruchi District with the Shakti-Surabhi

Bio-methanation plant at Surandai in Thirunelveli district, Tamil Nadu

The challenge of converting waste into wealth at Mamallapuram has been successful largely due to the joint efforts of a Chennai based NGO, 'Hand in Hand' and VK-NARDEP who set up a large plant. They collect about 550 to 600 kgs of kitchen waste to feed the plant which in turn generates 10 kW of electricity from this waste. Scientists and officials from the Tamil Nadu Agricultural University (TNAU), Coimbatore and Tamil Nadu Energy Development Agency (TEDA) have visited the project and sanctioned the prescribed subsidy from the Government. In Coimbatore and Puducherry too, large volume fixed plants are being constructed with the support of local organisations and institutes.

The Shakti Surabhi has struck a chord with housewives, institutions and communities alike and now with policy makers and domestic energy markets sitting up to take notice of the small flames ignited by this decentralised energy technology, this might just be 'the' answer to all of India's energy woes. ❂

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Towards a Disease-Free Village

A simple water disinfection system called 'Solar Mac™' has transformed the lives of the people of Namaswada Cuncoliem, a village in Goa, ridding them of water borne diseases.

Mangesh Bang

Ashwini, Sarpanch of the Namaswada Cuncoliem Village Panchayat, Goa is a happy woman who proudly states: "It is almost three years now and thanks to the Goa Energy Development Agency (GEDA), our village is free of water borne diseases. I am delighted to say that it is De Nora's Solar Mac™ that has made this possible. This water disinfection system has helped us to reach out and ensure germ free drinking water for all the villagers despite the fact that we are located in a relatively remote part of Goa. The daily operating costs are almost negligible and we are using this system to disinfect our water, on a regular basis".

The story of Namaswada Cuncoliem village is an example of how a people-government partnership can benefit an entire village. This village had access to the PWD supply of water, but it was inadequate or irregular. The other source available was spring water, and nearly 60-70 villagers were dependant on the Namaswada spring to meet their drinking water needs. This practice was being followed for years and had become a part of their daily lives. However as pollution levels began rising globally, the village too was affected with repeated bouts of illnesses. "But it did not occur to us that this was linked to the deteriorating quality of the spring water." recalls Ashwini.

> **In 2009 the Namaswada Cuncoliem Village installed a water disinfectant system that used common salt and helped villagers gain access to safe drinking water at a negligible cost.**

Diseases such as diarrhoea and gastroenteritis and even typhoid became frequent and reached their peak during the monsoons, causing grave danger to the families in the village. "I remember it was in the year 2008 that the officials at GEDA told us about the Solar Mac^{TM} system that would help common villagers like us access safe drinking water at a negligible cost." The Solar Mac^{TM} electrochlorinator requires only salt and water to generate low strength sodium hypochlorite. When added to water in appropriate quantities, the sodium hypochlorite inactivates bacteria and viruses, making the water absolutely safe for human consumption. It is a cheap, safe option that can disinfect 54000 litres of water a day at a nominal cost of 270 grams of salt per day.

A request to set up the Solar Mac^{TM} in the village was forwarded to the GEDA who saw promise in electrochlorination as a simple technology for disinfection of drinking water. The GEDA eagerly accepted the request and decided to supply the system free of cost to the Namaswada Cuncoliem Panchayat. After granting the work order in August 2009 to De Nora India Ltd, Goa for the supply, installation and commissioning with one year operation and maintenance of Solar Mac^{TM} system, it was successfully commissioned in October 2009. Treated water samples were then tested by the Department of Health, Goa as well as PWD, Goa and were certified safe for human consumption by both. The villagers witnessed an almost immediate decline in diseases after they started consuming this treated water. "After one year, in October 2010, our Panchayat took over the responsibility of operating the system independently and till date we are efficiently maintaining it with active support from De Nora," says Ashwini, with an air of achievement. The success story at Namaswada Cuncoliem has been covered by local TV channels and the print media. Those interested in getting to know more about this cost effective project can visit the village and witness the change. ❂

The water disinfectant unit in Namaswada Cuncoliem Village Panchayat, Goa

Drinking Water Project - Self-Reliant Approach of Namaswada Cuncoliem Village Panchayat: Our Heath in our Hands

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Boritakheda
Test Project in Amravati, Maharashtra

A successful tale of the installation of a 10 kW capacity biomass gasifier that has completely changed the outlook of the Korku tribal community in Boritakheda.

The trial run for the biomass gasifier at the Boritakheda test project was started in January, 2011 with the electricity generating systems being fully commissioned in March-April, 2011. Two Gasifiers of 10 kW capacity each, have been installed and commissioned in the Project. Boritakheda has a Korku ST population with 123 households and the village is situated at a distance of about 228 km from the district headquarters and 61 km from the block headquarter, Chikhaldara. Located in a remote region surrounded by forests and connected only by a 20 km long *kaccha* road which can be accessed by foot or by jeep in the off monsoon season, the Project comes as a boon. Implemented by DREAM Bahuddheshiya Sanstha, the Project is monitored and co-ordinated by Amravati and Maharashtra Energy Development Agency (MEDA). The biomass gasifiers meet the daily requirement of domestic lighting in 123 households, street lighting and other entertainment activities. Each household has been provided with two light points and one power point for domestic appliances. With the introduction of electricity, the lifestyle of the villagers has changed drastically. The Korku tribe living in this village is very hospitable to tourists and visitors visiting this place, their smiles indicating that their once distant dream of power connectivity is now fulfilled. The people especially women, can now work late evenings, as work hours are no longer restricted by the duration of daylight, which has resulted in an increase in their income. This has also greatly benefited students who can now study during the night. After the introduction of electricity, seven television sets have been purchased in the village. They watched the Cricket World Cup for the first time as power was now available in their village. The village is enjoying a good power supply for 6-7 hours each day from 7.00 pm to 2.00 am. With the introduction of Biomass Gasifier electricity, some more important livelihood activities have also been undertaken by the villagers, such as installation of '*atta chakki*' (flour mill) in the project which is in regular use and generates a monthly income of around Rs. 2000 to Rs. 5000. To operate the *chakki*, an operator is employed by the Village Energy Committee (VEC). A villager has just started a tailoring shop which he can now operate in the night too, due to the availability of electricity, which was seemingly impossible for him to do before. Earlier in fact he had to venture to distant places for the same to earn his livelihood. As the plantation is in the developmental stages, two villagers are engaged by the VEC for collection of wood from nearby areas which in turn has generated employment opportunities for them and two operators are engaged by the VEC for running the gasifiers, which also becomes an earning source for them. A retail shop has come up in the village which is run by a woman, in the evenings, which has become an additional source of income for her. ✪

Pandrass Electrified by the Sun

Kargil - A case study that is an explicit example of successfully harnessing the solar energy to power a 40 kW Solar Photovoltaic (PV) plant that supplies 8 to 10 hours of uninterrupted power to the residents of Drass, the second coldest place in the world.

The Drass sub-division is situated at a distance of 60 km from the District Headquarters of Kargil, which is the second coldest inhabited place in the world, temperatures plummeting to -40°C during winters. The village Pandrass is located at about 7 km from the sub-divisional headquarters and is home to nearly 80 households. During winters the village remains cut off for months from the rest of the district due to heavy snowfall, leaving the inhabitants to face the bitter cold on their own.

The Village was electrified with a 75 kV diesel generator (DG) set which supplies power for 4-5 hours each day. In order to minimise the high speed diesel (HSD) consumption, the Kargil Renewable Energy Development Agency decided to set up a 40 kW SPV Power Plant to increase the duration to at least 8-10 hours of uninterrupted power supply, apart from also being more cost effective as opposed to a DG set that consumes Rs. 600 worth HSD every hour. As part of the MNRE, 'Ladakh Renewable Energy Initiative' Project REDA, Kargil has installed and commissioned a 40 kW SPV Power Plant at Pandrass. After the installation of the 40 kW SPV Power Plant, the villagers are now getting continuous power from 5 pm to 8 am - enough to light 4 CFL bulbs of 15W for 14 hours. The inhabitants are elated with the supply and submitted a representation through their elected representatives to Ladakh Autonomous Hill Development Council (LAHDC-Kargil) to keep the installed DG set as only a standby, thereby saving significant amount of HSD and minimising the use of fossil fuel and mitigating the pollution fallout caused by the combustion, in an already oxygen scanty high altitude cold desert area. The SPV Power Plant is managed by the Electricity Management Committee (EMC) of the village. The charges are Rs 50 per household as tariff which is deposited in the joint account of the EMC. The amount deposited is meant for future maintenance and replacement of batteries of the Pandrasss SPV Power Plant. ✪

Renewables Bring Pichiliguda to the Forefront

An enlightening story about Pichiliguda a backward village in Orissa, and how a simple 37 W home lighting system in each household changed their lives creating a new hope for a brighter future.

The poverty ridden village of Pichiliguda, Bissamkatak Block of Rayagada District, lies in the remotest corners of Odisha. Development efforts often get crippled in these remote locations that are facing troubled situations from naxal insurgency. Situated 25 km from the block headquarters and 30 km from the nearest rail head, the tribals of this village have hardly any access to modern amenities. Low levels of literacy, malnutrition, child labour, infant mortality, migration and such other social deprivation is endemic to these areas.

Pichiliguda has a total population of 218 that lives in 47 households amongst which 46 belong to the Below Poverty Line (BPL) category. The villagers are mainly cultivators and labourers. The village has neither any small or micro enterprise nor even a shop. The block headquarter is the nearest and the only electrified area, Pichiliguda is still miles away from getting this facility. The only way to meet their illumination needs at night, is the use of kerosene wick lamps by rationing the little kerosene that is available through the public distribution system.

The State Energy Department states that the extension of the conventional grid to the village would neither be technically feasible nor commercially viable. However, the Energy Department recommended this village for inclusion under the Remote Village Electrification Programme (RVEP) which is currently being implemented under the Ministry of New and Renewable Energy (MNRE). Upon receiving the recommendation, the Odisha Renewable Energy Development Authority (OREDA) organised a village meeting (*Pallisabha*) in Pichiliguda on 21 June, 2009. A decision was made to provide 37W solar home lighting systems to each household and the community centre in the village, along with 5 Solar Photovoltaic (SPV) street lighting systems of 75W for installation in prominent places of the village. Thereafter, a detailed survey of the village was done by the OREDA and a detailed project report (DPR) was prepared at an estimated cost of Rs 9,03,360. Upon receipt of sanction from the MNRE the installation of the systems in the village was completed during November 2010. Two village youths as recommended by the Village Energy Committee were trained under the vendor company M/s Central Electronics Limited, in assembling and installing of solar lighting systems. Following a detailed verification of the installed systems by the members of the Village Energy Committee (VEC) and officials of OREDA, the systems were then formally handed over to the VEC. Now the village energy committee oversees the maintenance and upkeep of the systems. The trained village youths take care of routine maintenance of the systems. In case of any major problem the VEC informs the service centre of the vendor's company at Rayagada to take up the repair work. Every household gets reliable illumination for atleast 4 to 5 hours after dark and 5 street lights glow from dusk to dawn illuminating the village streets. After a very long wait there is now some light in the lives of these villagers. Now even after darkness one can notice children studying under the solar lamps , and women visiting one another's house, and performing various household chores like leaf stitching, cooking little late in an illuminated kitchen, etc., while men chat, hold meetings and roam around freely in the village without any fear of wild animals and many such other insecurities. Moreover, people are able to save a part of their expenditure that was earlier spent on the purchase of kerosene by them and to add to their joy there is also a significant reduction in indoor air pollution.

With government support in providing and installing solar home lighting systems, to Pichiliguda, the village now has a new outlook and is sensing a mild fragrance of urbanisation, and it is fair to say that this village is perhaps no more a 'pichadahua' or backward region anymore and holds a bright future. ✪

Micro-Hydel Project
Brings Smiles to Dhatmir

The micro-hydel project in Taluka is a success story of a community based power supply system.

The Taluka Micro-hydro Project, located in village Dhatmir in Block Mori of District Uttarkashi, which falls on the way to 'Har Ki Doon', presents a unique model of a community managed hydro power system. The basic idea behind the Project was to utilise the free flowing water of the perennial Gattu Gad stream for generating power and to supply continuous electricity to the hamlet Taluka, Tourist Rest House (TRH), Forest Guest House of the Govind Wildlife Sanctuary and the nearby market, on a sustainable basis. The Project has been conceived around a 'Community Participation' model. An Urja Energy Committee (UEC) was constituted which was involved with the Project from its initial phases including the planning and commissioning stages. A thorough training was provided to operators and electricians in order to handle the operations, distribution and safety aspects. The total power production of the Project is 20 kW and it provides power supply to 75 families through a distribution network of about 2.5 km.

The Project has been designed on 68 m net head and 0.04 cumec discharge and has a one pelton double nozzle turbine of 20 kW, synchronous generator of 20 kW/0.415kV, 16 m feeder cum headrace channel and penstock pipe of 180 m. Other structures such as the diversion, desilting tank, forebay tank and power house etc. have been constructed as per the designed requirement of the project. For operation and maintenance of the Taluka Micro-hydro Project, a local operator has been appointed by the UEC and a sum of Rs. 100 per connection is collected as the monthly electricity charges through appointed electricians at the Project site. The amount collected is used as the honorarium for the operator and for day to day maintenance charges. The UEC is also maintaining various documents such as a day book, bill collection register, log book, complaint register, stock register and bank documents etc.

Key Factors of the success

- Members of the UEC have been selected by villagers -UEC having legal status to penalise the defaulters.
- Regular salary to operators and technicians.
- Load management in peak hours.
- Regular account audits by certified chartered accountants.
- Insurance of project equipments. ❂

Pico Hydro in Karnataka

An enthralling story of a hydro-power plant that has brought new opportunities of employment and ease in the daily lives of the villagers in Chembu village in Karnataka.

There has been a significant change perceived in the energy scenario after the deployment of Pico Hydro Projects in Karnataka in the last 4 years. Pico Hydro are projects with a capacity upto 5kW especially targeted to benefit rural communities with access to small streams and rivulets. The developers of these projects are based in UK and from 2007 till date have installed around 400 Pico Hydro projects with the numbers increasing steadily with each passing day. By March 2012, the number of installations is expected to reach 500.

The hydro systems have positively impacted the lives of the villagers as it provides an uninterrupted power supply and fulfils their electricity requirements. A number of installations have been made in remote locations which have no grid connectivity. A 1 kW Pico hydro provides 24 kWh of 220 V, 50 Hz AC power per day and all available equipment can be used by farmers who have access to quality power. Equipment includes lights, TV, grinder-mixer and household items. Some of the villagers run small businesses on the power generated from the power plant as an income generating activity.

The Chembu village in Coorg District of Karnataka has seen a marked difference since the installations of the hydro systems. The village is surrounded by forests and is inhabited by poor farmers who previously had no access to electricity but had semi-perennial streams running through their habitation. Today, around 40 households in the village have installed these systems and have access to clean electricity throughout the year. The village is on its way to become a 100 per cent Pico Hydro-powered village.

The prospective beneficiary in a typical case of the installation process, applies through the website to the Karnataka Renewable Energy Development Ltd. (KREDL) with a registration fee expressing his intent to install a Pico Hydro system in his property. The applicant then identifies any of the implementing agencies who helps in getting bridge finance for the Project and also arranges for the installation of the system. After the setting up of an installation at site, a completion report is sent to the KREDL, who then sends its technical personnel to visit the site to check the installation and evaluate its performance to process the request for release to the end beneficiary.

Solar Energy Centre Embarks on Manpower Development

The Solar Energy Centre under the Ministry has been patronising various specialised training programmes with national and international participation.

The Solar Energy Centre (SEC) is one of the specialised centres of the Ministry of New and Renewable Energy (MNRE) focussing on R&D, testing and training in solar energy technology and applications. Established in the year 1982, the Centre has contributed significantly in the development of various solar energy systems and devices. In the late 1990s, the Centre initiated short-term training courses on various aspects of solar energy. The initial focus of these training programmes was on participants from State Renewable Energy Agencies, who were imparted training on system design, and operation and maintenance of solar photovoltaic (SPV) systems. The SEC expanded the scope of manpower development in the year 2005-06 by way of launching a Visitors Programme and organising trainings for varied target groups, such as students from various engineering/science colleges, industries, NGOs, financial institutions etc. Under the Visitors Programme, the SEC has facilitated students of various institutions to work at the Centre for a period of 2 to 6 months on their minor/major project works. In addition, the SEC has made provisions to provide stipend or fellowships to selected students working in the Centre on specific projects for a maximum duration of three years. This facility has greatly helped in providing a platform to students to expose themselves to practical training in the area of solar energy and subsequently opened employment opportunities in solar energy industries.

The SEC further expanded its training activities by organising specialised training programmes on solar energy for participants from various countries. It organised the first two of such programmes on its own wherein participants from five countries participated. The SEC was accredited as one of the training institutes under the Indian Technical and Economic Cooperation (ITEC), Programme of the Ministry of External Affairs (MEA) in the year 2008-09. Since then the SEC has organised four training programmes spanning over three weeks, under the ITEC umbrella. Workshops/orientation programmes on solar buildings were also conducted in Himachal Pradesh and Andhra Pradesh. Two experts of the SEC were even deputed to Mauritius to impart training on solar energy applications to 27 engineers from both private and public sectors of the Republic of Mauritius.

All these activities, clubbed with an expanded focus on application oriented research and developmental activities, is leading the SEC towards a new era, where it is gearing up to meet the challenge of a foreseeable future of meeting the increasing demand of trained manpower in the country and abroad.

MUNICIPALIKA 2012

CALL FOR SUSTAINABLE CITY DEVELOPMENT

An international conference and exhibition on green governance and sustainable urban development was held in Chennai. The event included a UK session seeking Indo-UK cooperation focussing on 50 per cent emission reduction.

MUNICIPALIKA
10th International Conference
'Good Urban Governance for Safe, Healthy
2012 Chennai
K P MUNUSWAMY

Municipalika 2012, the 10th International Conference on 'Good Urban Governance for Safe, Healthy, Green Inclusive and Smart Cities' co-terminus with the 10th International Exhibition on 'Urban Infrastructure, Sustainable Urban Development', held from 23- 25 January 2012 at the Chennai Trade Centre, concluded with a clarion call for sustainable city development urging the strengthening of initiatives for sustainable development of Chennai.

The event was attended by over 1200 delegates from 200 cities representing mayors, municipal commissioners, secretaries to governments dealing with municipal administration, local self government, urban development, and infrastructure development, housing, water supply, from cities, metros, and towns. It included urban professionals, technology and service providers, academia and other stake holders including civil society groups.

The function was inaugurated by, K. P. Munuswamy, Minister for Municipal Administration and Rural Development, Government of Tamil Nadu. The inaugural session was presided by R. Vaithilingam, Minister for Housing and Urban Development, Government of Tamil Nadu and Saidai Duraisamy, Mayor of Chennai.

One of the significant segments of the event was the Cities for the GenNext - a citizen interface with the theme of a sustainable Chennai and sustainable campuses held by the academia and the city commissioners with citizen groups. The three day event included topics on progressive, healthy and humane cities.

Each of the sessions highlighted the challenges, major initiatives and actionable agenda needed for creating sustainable and inclusive cities. The 12 sessions including a UK session had over 120 presentations by expert speakers followed by remarkable floor interventions.

The UK session discussed issues regarding the climate change challenge, seeking emission reduction by 50 per cent as world population rises by 50 per cent by 2050. A roll out of 53 million smart meters for 30 million homes and businesses by 2019 was targeted. A substantial scope for Indo-UK cooperation has been proposed. Municipalika 2012 also strongly endorsed the need for sustainable city development in different parts of India and also asserted the need to strengthen the initiatives taken for a sustainable Chennai. ⭘

SPRERI
Open House 2012

The Open House Programme included the latest advancements in green technology and the status of the currently accessible renewable sources with different working prototype models, exhibited by students and renewable energy product manufacturing companies.

The Sardar Patel Renewable Energy Research Institute (SPRERI) organised an Open House Programme on January 6-7, 2012, sponsored by the Ministry of New and Renewable Energy (MNRE), New Delhi. Dr. Basudeb Bakshi, Principal of Natubhai V. Patel College of Pure and Applied Sciences, (NVPAS) was the chief guest. Dr. Bakshi, in his inaugural address highlighted the present status, potential and limitations of currently accessible renewable sources and emphasised on a faster switch over to renewable energy sources, solar energy in particular, for its greater feasibility and utility value in the country. He stated that Gujarat has immense potential for harnessing the solar energy and the State has been initiating various programmes and projects to make optimum use of solar power in the region. Dr. Murari Shyam, Director, SPRERI briefed the gathering about the recent advancements in renewable energy technologies. All the scientists of SPRERI and 350 students from different schools and colleges along with their faculty participated in the inaugural event. Er. Tilak Chavda, Senior Scientist, Solar Energy Division, SPRERI welcomed the chief guest and Director, SPRERI. An exhibition was set up by school students displaying various innovative ideas in the form of actual working prototype models.

All the scientists, technical department and staff of SPRERI actively participated in the Open House Programme and made arrangements to put up working systems for display to the visitors. Around 2000 participants, mostly students from science, engineering and other disciplines from various schools and colleges all over Gujarat visited SPRERI. Some renewable energy product manufacturers such as Steelhacks industries, Sun Energy Systems, Redsun Solar industries, Sunfree Heat Industries and Taylor also demonstrated their products in the display.

SPRERI technologies like solar absorption refrigeration system for ice making, forced circulation solar dryer, dual axis sun tracker for SPV power generation, producer gas-based power generation system, inverted downdraft biomass cooking stove, briquette machine, biogas production from jatropha oil cake, biomethanation system and anaerobic filter were the main attractions for the visitors at the Open House. ❂

Akshay Urja Aur Hum

> "Thanks for presenting such a great programme on Renewable Energy, it's really very informative and I will certainly follow the things discussed in the programme." - **Mr. Mahesh Jain, Delhi**

> "The Programme is very nice and this type of education is very much needed at this hour."- **Mr. M. Levy**

> "I am grateful to tell you that your programme is the best. I listen to it every morning when I am going to college. Your programme on radio is very informative and I like to hear it. I request to you to increase the time of the programme to 20 minutes to answer our questions". - **Mr. Mayank H. Bhavsar**

> "The Programme helps spread awareness about the advantages of using environmental friendly products. The anchors of this programme conduct the programme in a way that encourages people to opt for green products."
> **- Mr S Prabhakaran, Namakkal, Tamilnadu.**

> You are presenting a wonderful programme and it's providing a wide range of information about new sources of energy."
> **-Ms Manisha Jain, Uttam Nagar, Delhi**

> "I listen to your radio programme regularly. It is very helpful and informative. I am inspired to use renewable energy products. In fact, I have installed solar heaters at my home."
> **- Mr. Vinayak Jangam, Andheri Mumbai**

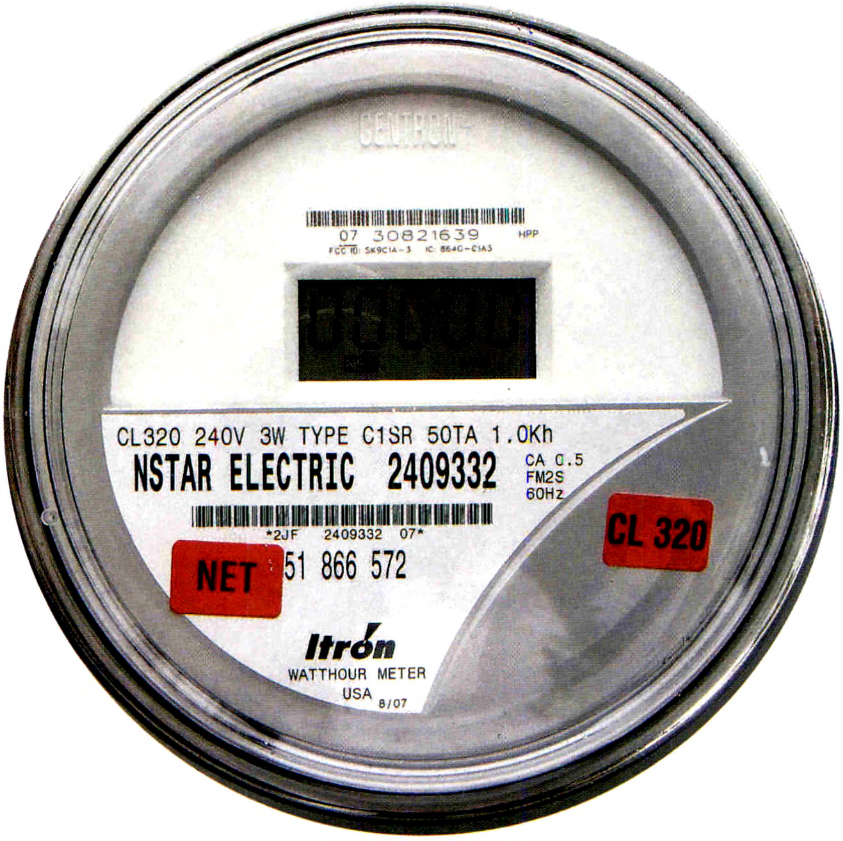
The Ministry launched a Radio sponsored programme on renewable energy entitled "Akshay Urja aur Hum", with on air running time of 15 minutes, entailing 52 episodes which were broadcasted on 50 primary and F.M. channels of All India Radio in Hindi and 17 other regional languages, during the year 2011-12, in major cities through the National Film Development Corporation Limited (NFDC). The Programme, highlighted the uses, benefits, financial incentives and subsidies on various systems, devices and technologies, along with covering all functions entrusted to the Ministry.

The programme also included a quiz, asking one question at the end of the programme. The winners were selected by lottery system, and rightfully awarded with a sum of Rs. 1000. The ongoing programme has been receiving enormous response from the public. The feedback has been extremely positive and encouraging. This is substantiated by the receipt of thousands of letters and e-mails by NFDC from listeners from all corners of India. ✪

Courtesy : Mr Nimai Ghatak, MNRE

NET METERING

Net metering comes as a new concept that promises an environment friendly and power efficient electricity evaluation system. It provides an easy option to produce electricity from renewables and also to get connected to the grid at the same time.



Net metering is a new concept where an instrument which has a special metering and billing agreement between utilities and their customers, facilitates the connection of small, renewable energy-generating systems to the power grid. This new programme is being developed to encourage small-scale renewable energy systems to ensure that customers always have a reliable source of energy even when their renewable generators are not producing energy, and to provide substantial benefits to the electric power-generating system as well as the environment.

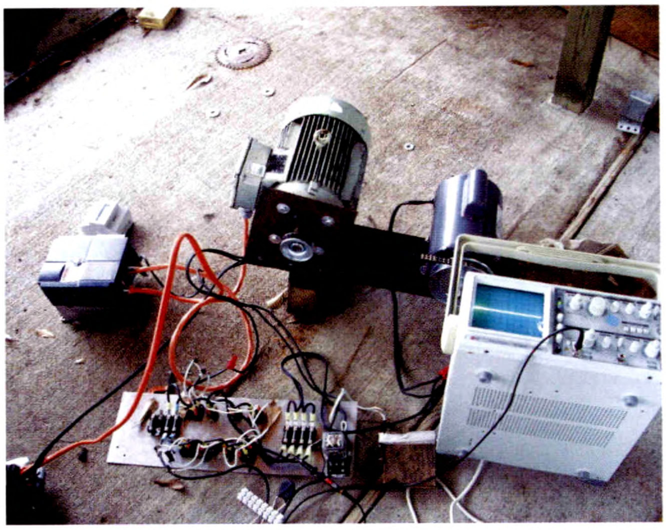
When a net metering client's renewable generator is producing more power than is being consumed, the electric meter runs backward generating credits. Whenever the net metering customer uses more power than is being produced, the meter runs forward normally. Net metering customers are charged only for the net power that they consume from the electricity service provider that has accumulated over a specific period. In other words, if their renewable energy-generating systems make more electricity than is consumed, they may be credited or paid for the excess electricity contributed to the grid over that same period. Net metering is also a way to increase the energy in the power grid to keep up with increase in demand during peak power use times, and this is of particular interest to states facing power shortages.

In a recent development, the Ministry of New and Renewable Energy (MNRE) undertook a national consultation on net metering for grid-tied PV projects, where officials from central ministries, secretaries of state regulatory commissions and officials from state power departments and distribution companies came together to prepare an action plan with practical solutions for the introduction of net metering. The Ministry has also planned a project which can be tried on a pilot basis in a few cities in India. The MNRE is trying to collaborate with companies, the municipalities and the state governments to agree to this project. The groundwork and seeking consent from the building owners has to be done either by the municipal body or by the distribution company or by any other state government agencies. There will be no extra burden on the distribution company if capital subsidy is provided. Using the net metering system will ensure that the house owner gets assured power supply during the day and this will get cheaper over the long period.

Although net metering system is a new concept in India, this programme is successfully working in countries like Australia, Canada, Italy, Spain, Denmark and United States. In 2002, Thailand was the first country to initiate the first net metering policy in the developing world. The Very Small Power Producer (VSPP) regulations were aimed at encouraging the use of small scale renewable generation almost under 1 MW. The Thailand Government mandates the purchase of any surplus electricity generated through renewables at rates which are adjusted every three months. The VSPP programme covers production from a variety of sources including Solar Photovoltaic (SPV) and bioenergy. The initial legislation was extended in 2006 and now includes mandates on the purchase of electricity derived from production of upto 10 MW.

Another successful use of the net metering system may be seen in Canada, which started in 2006. The first net metering site for demonstration was chosen in the rural community of Knowlesville near Hartland in 2004. Now Canada has adopted the net metering system and it is available for all. California, US, is also using the net metering systems successfully. Residents of California also have the option to live off-grid and use renewable energy as stand-alone systems instead of incurring expenses for long distance wire connections. Other residents have the additional opportunity to install their own systems that are linked to the grid through net-metering which is also known as grid-intertied.

Net metering can increase the energy in the power grid to keep up with demands during peak times, which is of particular interest to states facing power shortages.



In India, this concept could be an important incentive for consumer investment in onsite renewable energy generation and also a motivating factor for consumers to utilise renewable energy. The MNRE plans to start net metering systems in India soon. The Karnataka Renewable Energy Development Ltd (KREDL) has stated that Karnataka is poised to develop the concept. The West Bengal Renewable Energy Development Agency (WBREDA) has put a 25 kW Grid Interactive Roof Top SPV Power Plant in place, where the net metering concept has been adopted and a MoU has been signed with the State Electricity Board. The Rajasthan Renewable Energy Cooperation Ltd. (RRECL) is planning to start an Urban Development and Housing Project (UDH) where the net metering system will be used as also the Renewable Energy Agency of Puducherry (REAP). The concept is new and innovative and provides low cost and easily administered methods for encouraging customers to invest in renewable energy technologies. Adopting this technology will herald a new era for India and create an interface that can significantly reduce the rising carbon footprint of the nation.

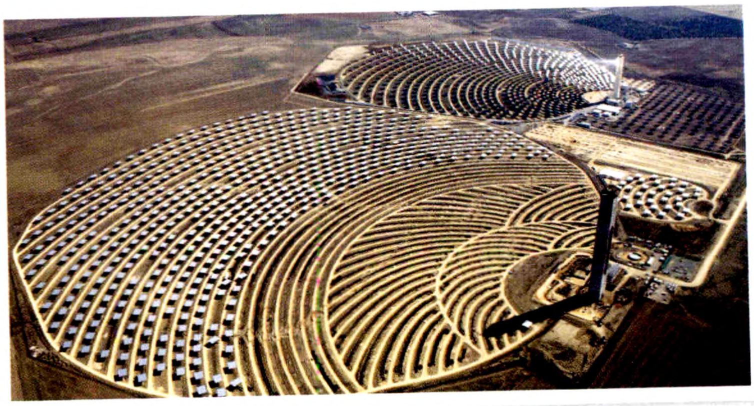
Courtesy: Arun K Tripathi, Director, MNRE & www.solarserver.com

New Sunflower-Inspired Pattern Increases Concentrated Solar Efficiency

In the desert region of Andalusia, Spain, sits an oasis-like sight: a 100 metre high pillar surrounded by rows of giant mirrors rippling outward. More than 600 of these mirrors, each the size of half a tennis court, track the sun throughout the day, concentrating its rays on the central tower, where the sun's heat is converted to electricity - enough to power 6,000 homes.

The sprawling site, named PS10, is among a handful of concentrated solar power (CSP) plants in the world. Now, researchers Noone and Mitsos from Massachusetts Institute of Technology (MIT), in collaboration with Manuel Torrilhon of RWTH Aachen University in Germany, have come up with a design that reduces the amount of land required to build a CSP plant, while increasing the amount of sunlight its mirrors collect. The researchers found that by rearranging the mirrors, or heliostats, in a pattern similar to the spirals on the face of a sunflower, they could reduce the pattern's 'footprint' by 20 per cent and increase its potential energy generation. The sunflower-inspired pattern allows for a more compact layout, and minimises heliostat shading and blocking by neighbouring mirrors.

The researchers published their results in the journal *Solar Energy*, and have recently filed for patent protection.



Concentrated Solar Power (CSP) Plant

Blocking a shadow

Mitsos' lab developed a computational model to evaluate the efficiency of heliostat layouts. The model divides each mirror into discrete sections and calculates the amount of light each section reflects at any given moment. The researchers tested the model on an existing commercial scale CSP plant. The group found that the CSP plant experiences a significant amount of shading and blocking each day despite the staggered layout of its mirrors.

Spiralling out

To increase the plant's theoretical efficiency, Noone and Mitsos tinkered with the pattern of heliostats, using numerical optimisation to first bring the fanned-out layout closer together. This narrower layout, the model calculated, reduced the amount of land the mirrors took up by 10 per cent without affecting the mirrors' efficiency in reflecting light. The resulting pattern had some spiral elements similar to layouts in nature.

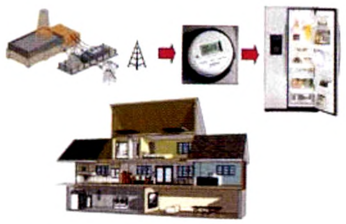
So the MIT team, working with Torrilhon, looked to nature for inspiration - specifically, to the sunflower. The florets of a sunflower are arranged in a spiralling pattern, known as a Fermat spiral, that appears in many natural objects and has long fascinated mathematicians - with each sunflower floret turned at a 'golden angle' - about 137 degrees - with respect to its neighbouring floret.

The researchers devised a spiral field with its heliostats rearranged to resemble a sunflower, with each mirror angled at about 137 degrees relative to its neighbour. The numerically optimised layout takes up 20 per cent less space than the PS10 layout. The spiral pattern also reduced shading and blocking and increased total efficiency compared with PS10's radially staggered configuration.

Arranging a CSP plant in such a spiral pattern could reduce the amount of land and the number of heliostats required to generate an equivalent amount of energy, which could result in significant cost savings. "Concentrated solar thermal energy needs huge areas," adds Mitsos, "if we're talking about going to 100 per cent or even 10 per cent renewables, we will need huge areas, so we better use them efficiently."

GREEN PRODUCTS

Smart Grid Appliances



Seizing opportunities to get in on the action and help consumers save money, Whirlpool and GE are introducing SmartGrid-enabled appliances that can be controlled from afar by the power company. They will soon have the power to lower thermostats, switch appliances into energy-saver mode, or shut them down entirely during times of peak demand. Whirlpool predicts that it will put one million smart clothes dryers in the market soon.

www.greenadvisor.com

Biobased Products

Ottman's client, the USDA, just last month announced its new 'USDA Certified Biobased Product' label, heralding a new era in consumer products and packages. 'Biobased' is defined by the USDA as non-edible consumer and commercial products that are based on agricultural, marine or forestry-based raw materials. Indeed, given our nation's agricultural abundance and with energy independence a growing imperative in the U.S., it just might signal the dawn of a new 'biobased' economy.

Ideas include creation of compostable gardening bags made from cornstarch, lip balm made from soyabeans, and even towels and bed sheets made with eucalyptus fibre. New recyclable 'plant bottle' (made of 30 per cent sugar cane), and chips package made from corn would herald new beginnings.

www.cleanlink.com

Indoor Composting

A great innovation in home design is a Parasite Farm – a product with a gross name but a cool function, allowing for even the smallest of kitchens to incorporate smart composting into its waste system. The Farm includes several planter beds with grow lights, and a compost bin with a chopping board lid that can be mounted on any kitchen table.

www.solarfeeds.com

Fuel Cells

Apple recently put a patent on fuel cell technology in laptops, in an attempt to curb the world's reliance on fossil fuels. Hydrogen fuel cells not only boast longer life than batteries, but are also capable of running on a single charge for weeks without requiring a recharge. The company is putting big bucks into the research of this relatively new concept under the guidance of their Electronic Product Environmental Assessment Tool.

www.inhabitat.com

Energy Management Devices

Eco-innovative appliances and devices that will enable significant energy conservation progress than that afforded by motion detectors and dimmers are now coming into the market. DIY Kyoto's Wattson is one of many such devices that help to monitor a household's electricity use. When the dishwasher starts, Wattson glows red and when the AC, is turned off the Wattson turns green. Many electric utilities, electrical product manufacturers, government bodies, software manufacturers including Microsoft and even Google are now working to transform the nation's power grid into one digitally controlled Smart-Grid network that can convey electricity to consumers more efficiently, cutting pollution and electric bills in the process.

www.triplepundit.com

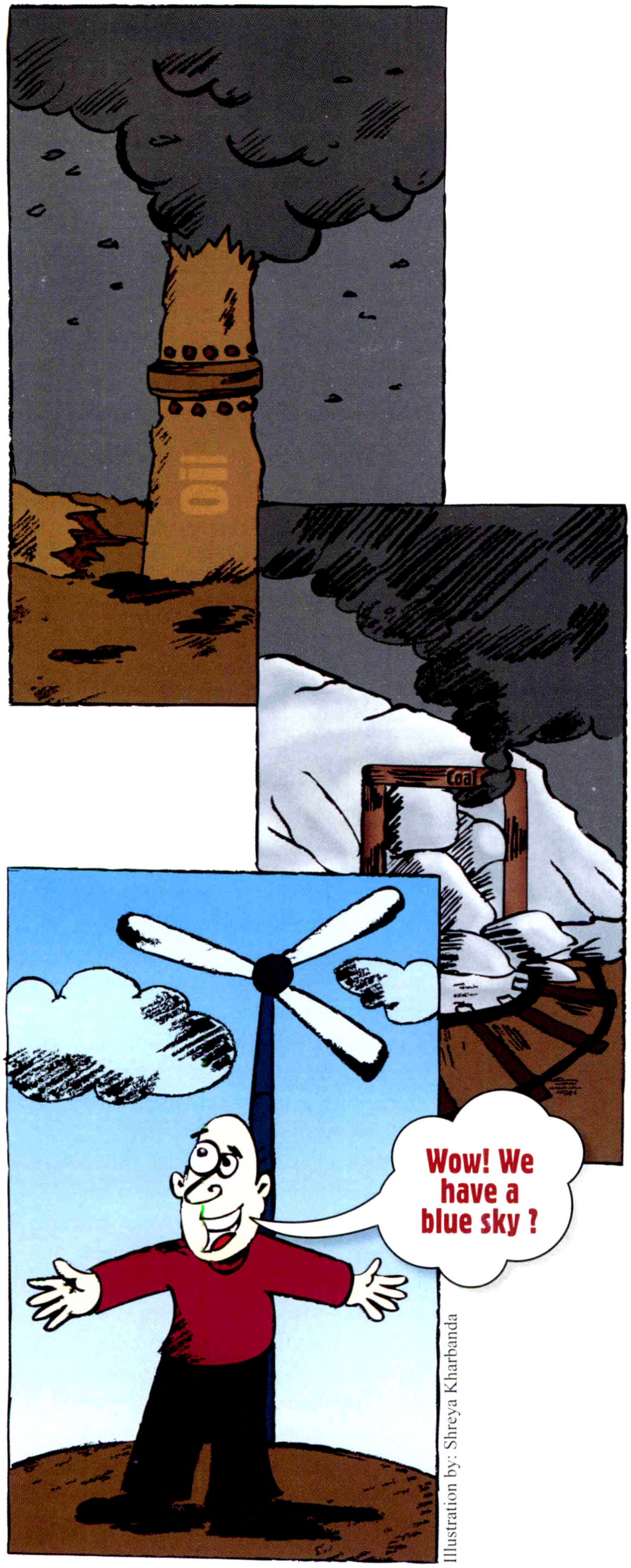

Oil
Coal
Wow! We have a blue sky ?

Illustration by: Shreya Kharbanda

Inviting articles for Akshay Urja

The need to have a sustainable supply necessitates the exploitation of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. RE can play an important role in resolving the energy crisis in urban areas to a great extent. Today RE is an established sector with a variety of systems and devices available for meeting the energy demand of urban inhabitants, but there is a need to create mass awareness about their adoption. Akshay Urja is an attempt to fulfil this need through its dissemination of 20,000 copies in India and abroad. The magazine publishes news, articles, research papers, case studies, success stories, and write-ups on RE. Readers are invited to send material with original photographs and statistical data. The photographs should be provided in high resolution files on a CD or through email. Akshay Urja will pay a suitable honorarium to the authors for each published article of 1500 words and above. The publication material in two copies, along with a soft copy on CD/DVD/e-mail may be sent to

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www.mnre.gov.in, E-mail aktripathi@nic.in

Potato Clock

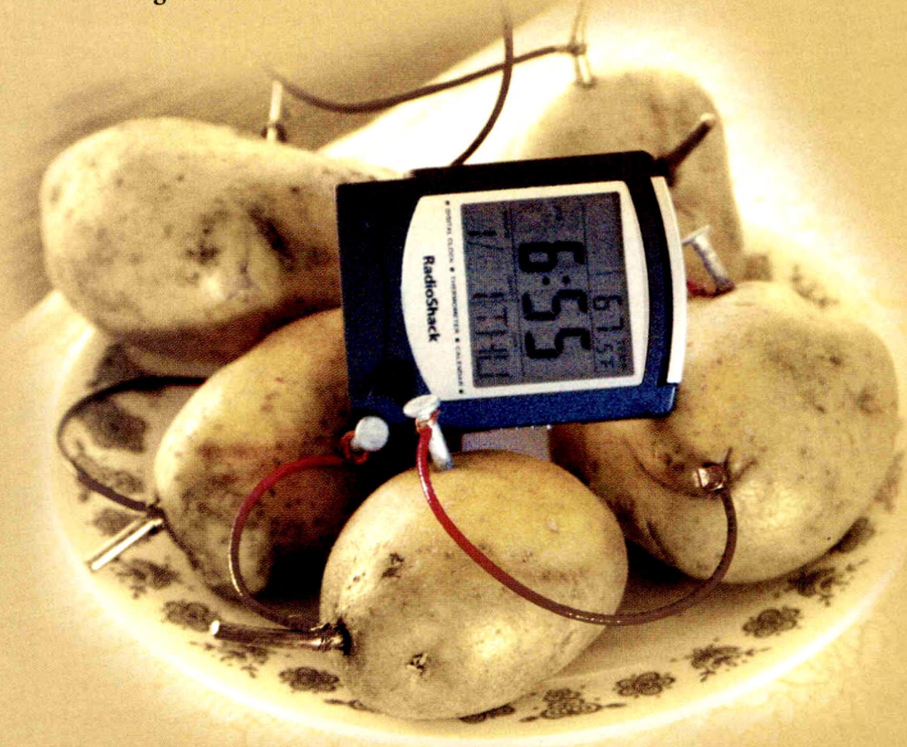
Your parents told you not to play with your food but they never said anything about not conducting a fun experiment with them!

Theory

The potato clock works on the concept of 'Redox' reactions. Short for 'reduction-oxidation', these are the reactions where the electrons lost at one terminal (called electrode) are taken up by the other terminal. An electrochemical battery stores chemical energy that changes into electrical energy that runs electronic equipment. There is a chemical reaction within the potato battery that causes the electrons to move. The electromotive force within each potato is the ability it carries to move electric current. In an electrochemical cell, such as the potato battery, the copper wire makes the electrons move in the potato, causing energy to move into the clock.

Things you will need

- **2 potatoes (or you could slice one potato into two halves)**
- **2 short lengths of copper wire**
- **2 galvanised nails**
- **3 alligator clip wire units (alligator clips connected to each other by wires)**
- **1 low voltage led clock**



Procedure

1. Insert a galvanised nail into each potato or each half of the potato.
2. Insert a short piece of wire into each potato. Make sure that the wire is inserted as far away from the nail as possible.
3. Use an alligator clip to connect the copper wire of one potato to the positive (+) terminal of the clock's battery compartment.
4. Use another alligator clip to connect the nail of the other potato to the negative (-) terminal of the clock's battery compartment.
5. Use the third alligator clip to connect the nail in the first potato to the copper wire in the second potato.
6. Set the time in your clock and amaze your friends and parents!

Website

Solar Energy Research and Consultation

www.solarbuzz.com

The Solarbuzz, an NPD Group company, is the industry's premier source for exclusive news, research, analysis and consulting. An interactive and informative site where market participants talk online in order to grow their market share. New entrants to the industry can also enlist for a rapid ramp-up to obtain the market intelligence that they need, to secure funding. With the office based in USA, the site hosts various global governmental consultations that help develop solar energy programmes.

New electric car web site

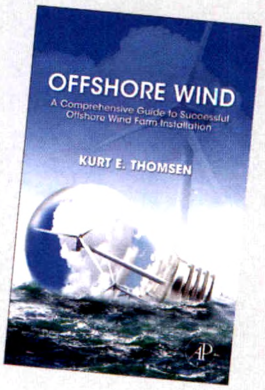
www.nissan-leaf.net

A new website lists the latest news on the Nissan Leaf Electric Car and also has separate sections on Nissan Leaf related discussions. Nissan Leaf reviews, blogs, and a forum was launched in December 2011. The forum is a hub where users can discuss all the latest news on buying or leasing electric cars.

RE tech for the young

www.re-energy.ca

Green Learning Canada envisions a generation of young persons who are inspired to actively create a sustainable world. The website, re-energy.ca, invites students of all ages to detailed construction plans on how build working models of wind turbines, solar ovens, hydroelectric generators, and biogas generators. Students can also make use of related links and backgrounders in RE basics, solar heat, solar electricity, wind power, water power, biomass energy, and other clean energy technologies.


OFFSHORE WIND
A Comprehensive Guide to Successful Offshore Wind Farm Installation
KURT E. THOMSEN

Offshore Wind

A Comprehensive Guide to Successful Offshore Wind Farm Installation

by **Kurt Thomsen**

Hardcover 352 pages
Cover Price: USD 99.95
Publisher: ELSEVIER
Year 2012
ISBN: 978-0-12-385936-5

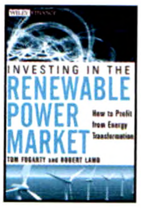
This book provides a ready reference for wind project managers, teaching them how to deal with complications on-site, as well as for financers, who can utilise the text as an easy guide to asking the pivotal questions of petitioning wind project developers. Wind turbine manufacturers will benefit from insights into design optimisation to support cheaper installation and hauling, thereby incurring lower project costs, and helping developers establish a quicker route to profitability. The book sheds light not just on HOW to solve a particular installation difficulty, but delves into WHY the problem may best be solved in that way.

Smart Grid

Integrating Renewable, Distributed & Efficient Energy

by **Fereidoon P. Sioshansi**

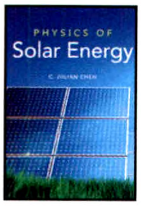
Hardcover: 568 pages
Cover Price: USD 99.95
Copyright 2012
Publisher: Academic Press Title
ISBN: 978-0-12-386452-9



Investing in the Renewable Power Market: How to Profit from Energy Transformation

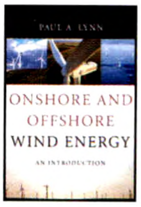
by **Tom Fogarty, Robert Lamb**

Hardcover: 224 pages
Cover Price: USD 74.95
Publisher: Wiley
February 2012
ISBN: 978-0-470-87826-2



Physics of Solar Energy

C. Julian Chen
ISBN: 978-0-470-64780-6
Hardcover
352 pages
July 2011
USD 139.95
Publisher: Wiley



Onshore and Offshore Wind Energy: An Introduction

by **Paul A. Lynn**

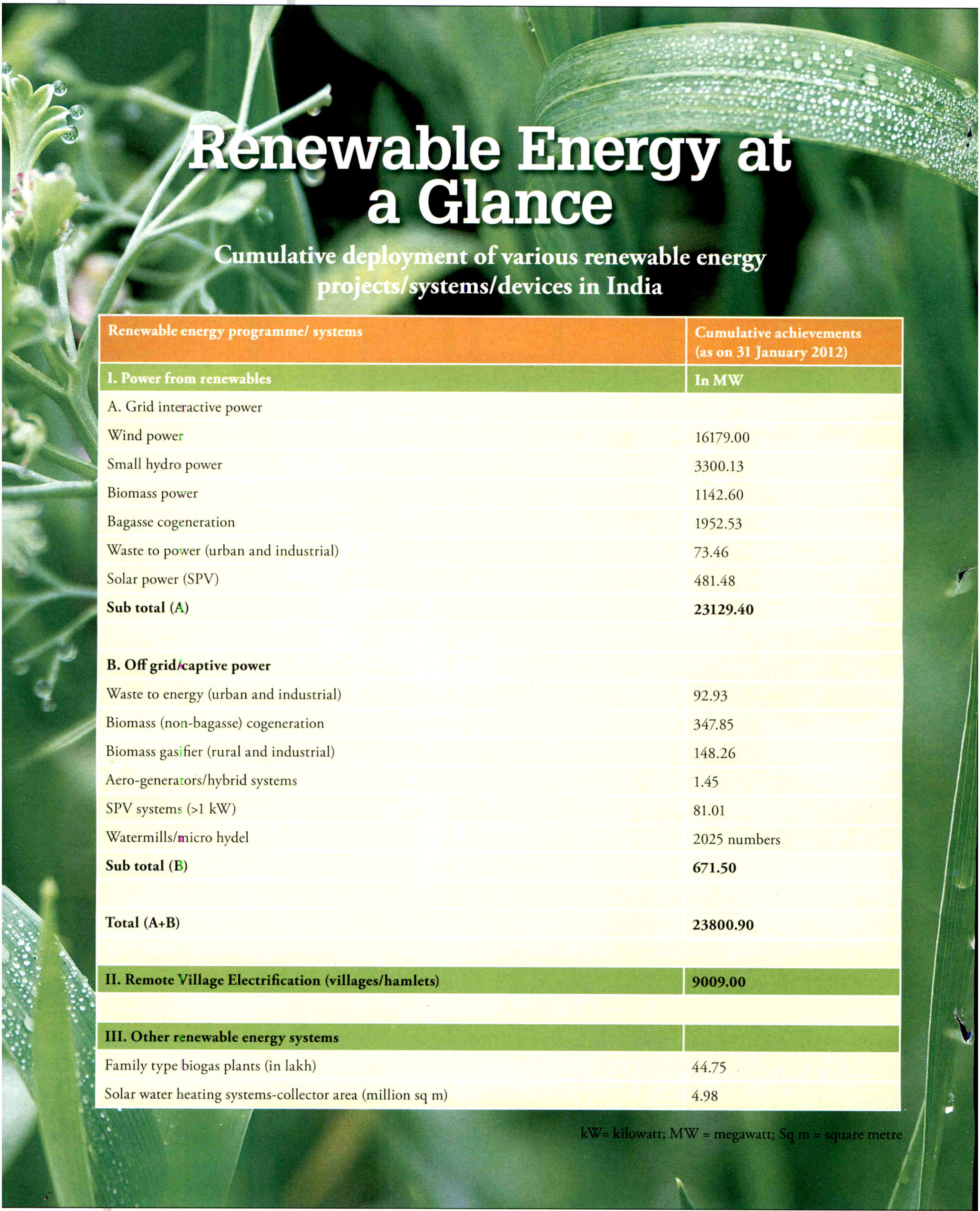
Hardcover: 240 pages
Cover Price: USD 80.00
Publisher: Wiley
December 2011
ISBN: 978-0-470-97608-1

National

12- 13 March 2012	REENERGY 2012 International Renewable Energy Conference & Exhibition Place: Chennai Trade Centre, Tamil Nadu Organiser: Tamil Nadu Energy Development Agency (TEDA) Contact: 91 - 89392 60979 or teda@renergy2012.com Website: www.renergy2012.com
14 - 15 March 2012	Third Concentrated Solar Thermal Power Summit India Place: Gurgaon, Haryana Organiser: CSP Today Contact: +44 (0) 20 7375 7556 Website: www.csptoday.com
17 - 18 March 2012	National Symposium on Plant Biology and its Role in Sustainable Food and Energy Production Place: Bilaspur, Chhattishgarh Organiser: Guru Ghasidas Vishwavidyalaya, Department of Botany Contact: 91-7752-260471 (O), 91-7587194631 (Cell) or ggvbotany@gmail.com Website: www.ggu.ac.in
2 - 4 April, 2012	5th International Battery Expo & Recycling Conference (IBRX India 2012) Place: Hyderabad, Andhra Pradesh Organiser: Pearl Exhibitions Conferences & Conventions Contact: 91-11- 23351630 Website: www.bfi.org.in
19 - 21 April, 2012	Renewable Energy World India 2012 Place: Pragati Maidan, New Delhi Organiser: Inter Ads Exhibitions Pvt. Ltd Contact: 91 124 452 4231, 91 783 833 7572 Website: www.renewableenergyworldindia.com
25 - 27 April 2012	Third International Conference and Exhibition: World Renewable Energy Technology Congress Place: New Delhi Organiser: Energy and Environment Foundation Contact: (011) 011-24538318, 22758149, 9971500028 or dranilgarg2011@gmail.com Website: www.wretc.in

International

5 - 6 April 2012	Solar Energy in Eastern Europe and the CIS - CISOLAR 2012 Place: Odessa, Ukraine Organiser: Renewable Energy Centre Contact: +38 044 498 90 57 or lena.pustovoyt@rencentre.com Website: www.rencentre.com
6 - 8 April 2012	The 6th China Qingdao International Building Energy Saving & Renewable Energy Utilization Fair Place: Qingdao, China Organiser: Qingdao Haichen International Expo. Co., Ltd. Contact: +86 532 80791023, +86 0532 83951056 Website: www.qdcese.com
11 - 13 April 2012	ICEESD 2012: International Conference on Energy, Environment, Sustainable Development Place: Venice, Italy Organiser: World Academy of Science, Engineering and Technology Contact: +971559099620 or info@waset.org Website: www.waset.org
16 - 18 April 2012	Technoport RERC (Renewable Energy Research Conference) 2012 Place: Trondheim, Norway Organiser: Technoport and the Centre for Renewable Energy Contact: +47 922 55 820 or coordinator@sffe.no Website: www.technoport.no/conference-2012
17 - 20 April 2012	2nd European Energy Conference Place: Maastricht, Netherlands Organiser: The European Science Foundation, the European Materials Research Society and the European Physical Society Contact: m.grispen@mecc.nl Website: www.energy-conference.eu



Renewable Energy at a Glance

Cumulative deployment of various renewable energy projects/systems/devices in India

Renewable energy programme/ systems	Cumulative achievements (as on 31 January 2012)
I. Power from renewables	**In MW**
A. Grid interactive power	
Wind power	16179.00
Small hydro power	3300.13
Biomass power	1142.60
Bagasse cogeneration	1952.53
Waste to power (urban and industrial)	73.46
Solar power (SPV)	481.48
Sub total (A)	**23129.40**
B. Off grid/captive power	
Waste to energy (urban and industrial)	92.93
Biomass (non-bagasse) cogeneration	347.85
Biomass gasifier (rural and industrial)	148.26
Aero-generators/hybrid systems	1.45
SPV systems (>1 kW)	81.01
Watermills/micro hydel	2025 numbers
Sub total (B)	**671.50**
Total (A+B)	**23800.90**
II. Remote Village Electrification (villages/hamlets)	**9009.00**
III. Other renewable energy systems	
Family type biogas plants (in lakh)	44.75
Solar water heating systems-collector area (million sq m)	4.98

kW= kilowatt; MW = megawatt; Sq m = square metre

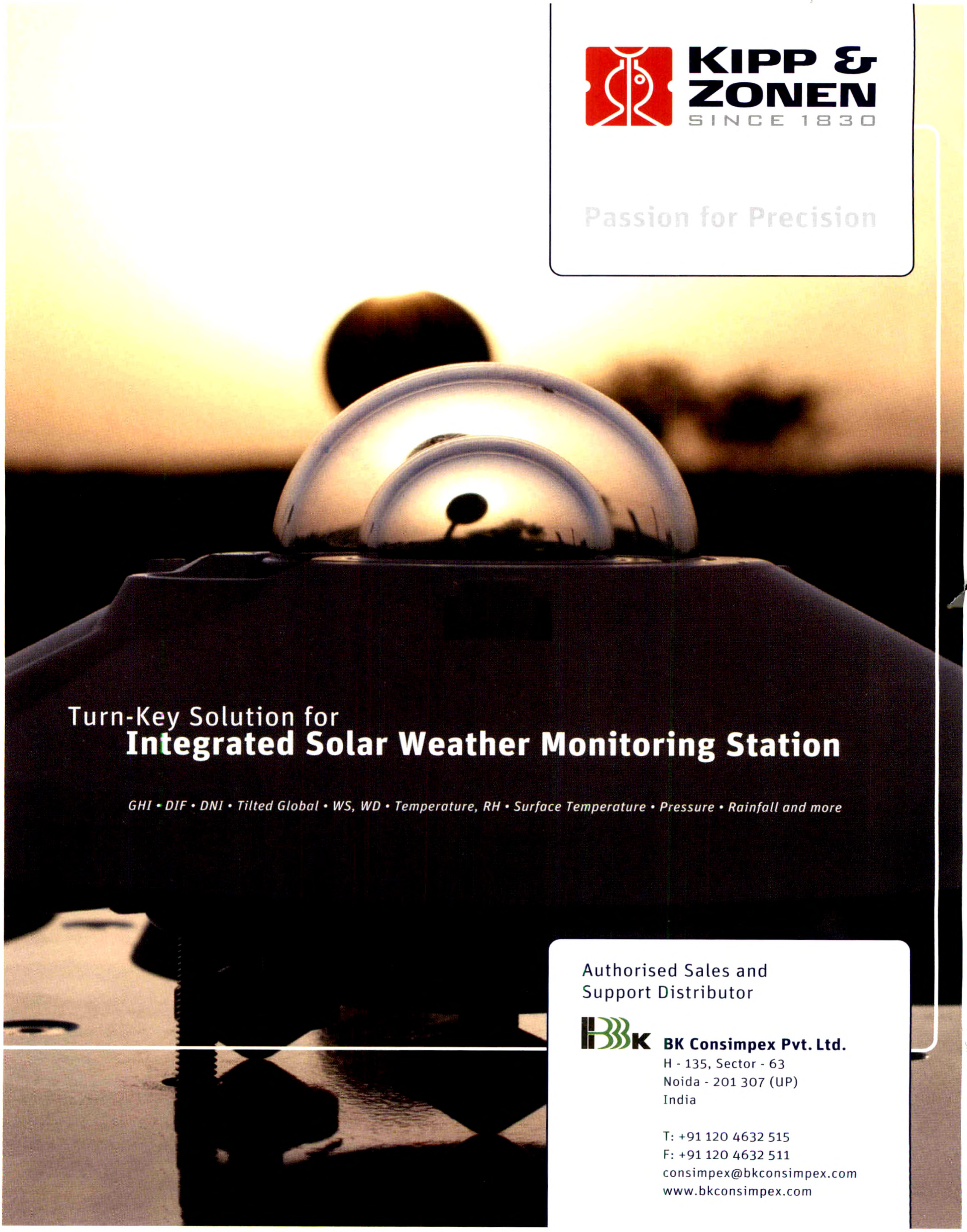
सत्यमेव जयते
Ministry of New and Renewable Energy
Government of India

Volume 5 ■ Issue 5 ■ April 2012

Renewable Energy
Akshay Urja
www.mnre.gov.in

NEW RENEWABLES

- Geothermal Energy
- Ocean Thermal Energy
- Hydrogen Fuel
- Compressed Biogas



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Renewable Energy
Akshay Urja

Volume 5 ▪ Issue 5
April 2012

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(Published in English and Hindi)

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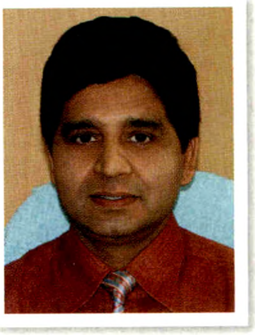
From the Editor's Desk



Dear Readers,

The use of renewable sources of energy like solar, wind, hydro in meeting our day to day energy requirements including electricity is now a known phenomenon and about 11.5 per cent electricity generating installations are from renewables in our country. Renewable energy contributes to mitigate the rapid degradation of the environment. Science has played a stellar role using innovative technology to discover new renewable energy sources, like fuel cell, biofuel, geothermal, ocean thermal energy and electric battery operated units, making renewable energy usable for everything from complicated processes to common place activities. The development of new sources of energy, although, at an initial stage, yet has an enormous potential. The Government is making efforts to make it commercially viable.

Amongst new resources, geothermal energy, hydrogen energy, fuel cell technology, biofuels, electric vehicles are the prominent areas where a breakthrough is expected shortly. In this context, the present issue has been prepared on new renewables. This issue of Akshay Urja promises its readers a wealth of information on new technologies with contributions from India's best known scientists and people who have been involved with current technology which is trying to bridge the gap between knowledge and the inspiring vision of setting the world free from sole dependence on fossil fuels, and the blight of pollution and environment degradation. The features on evolution of geothermal energy, geothermal scenario in India, ocean thermal energy with information on harnessing ocean energy in the form of waves, currents, and tides and how ocean thermal energy conversion (OTEC) can be used as a technology that utilises temperature differences to extract energy from the oceans have been presented. The areas such as electric vehicles, hydrogen energy and fuel cell technology which have proven to be by far path breaking, have been covered in an interesting manner.

I am sure that readers will find it informative, useful and interesting. Please do send your observations and critical comments about this issue. I wish all our readers a happy reading !

अक्षय ऊर्जा से देश विकास

AKTripathi

ARUN K TRIPATHI
<aktripathi@nic.in>

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Letters to the Editor

We wish to receive Akshay Urja, the bi-monthly newsletter in order to create awareness regarding renewable energy resources in our State especially in the region of Hyderabad-Karnataka. The newsletter contains very valuable and detailed information about new projects, functions, scheduled plans, features, research, international news etc., pertaining to the new and renewable energy sector. Hence, it will be indeed helpful for us to share the information with the rural people in addition to creating awareness about new and renewable energy resources.

Deputy General Manager
Karnataka Renewable Energy
Development Ltd.,
Gulbarga, Karnataka

We are writing to you from the Dr. Ambedkar Institute for Handicapped,U.P. It is the only Institute in North India (designed barrier-free) that imparts technical education to handicapped students, awarding degrees in computer science, electronics, chemical engineering, IT and Biotechnology since 2004. The Institute will be grateful to you for accepting our request of sending us the newsletter on a regular basis for the welfare of the students.

Dr. Gaurav Chandra
Director, Dr. Ambedkar Institute
of Technology for Handicapped,
Kanpur

I am pleased to know that the Ministry of New and Renewable Energy brings out such an interesting and informative newsletter like Akshay Urja. I am writing from the Pinkcity Engineering College and Research Centre, Jaipur. We would like to receive Akshay Urja on a regular basis, so that our students and faculty can know and learn the value of energy conservation and renewable energy sources along with the capacity of various non-conventional power plants. We look forward to your reply.

Prof. M. Lalwani
Pinkcity Engineering College
and Research Centre,
Jaipur, Rajasthan

I would like to introduce myself as an Asst. Manager (Environment) working in Kolkata. I am very interested in new and renewable energy sources and I find that the Akshya Urja magazine is very informative and useful for me. I wish to subscribe to your magazine. You are requested to please suggest the procedure and formalities for the same.

Rohan Kumar Mehto
Kolkata, West Bengal

I am passionate about renewable energy studies. I have been reading your newsletter for the last two months and I am delighted with the knowledge that I have gained. I want to extend my heartfelt congratulations and thanks to the editor and the entire team of Akshay Urja for their in-depth analysis related to the field of renewable energy and for compiling the newsletter so wonderfully. I would also like to express my deep interest to be included in your group of niche readers of Akshya Urja and would like to subscribe to the newsletter.

Pratik Mor
Ber Sarai, New Delhi

आप पूर्वानुकूल अच्छा कार्य कर रहे हैं। एतदर्भ आभार, हमने एन एस एस के माध्यम से गेल से धनराशि प्राप्त आदिवासियों के एक गाँव को सौर ऊर्जा के प्रकाश से जगमगाने में सफलता प्राप्त की है। आशा है, अक्षय ऊर्जा इसी प्रकार नियमित एवं समय पर मिलती रहेगी।

सतीश चतुर्वेदी
सिसौदिया कालोनी गुना,
मध्य प्रदेश

आपकी मासिक प्रत्रिका निरन्तर इसी प्रकार महाविद्यालय में प्राप्त होती रहे जिससे आदिवासी क्षेत्र में अध्ययनरत् छात्र/छात्राओं को उत्कृष्ट ज्ञान प्राप्त हो सके। इसी आशा एवं विश्वास के साथ सम्पूर्ण महाविद्यालय परिवार की ओर से आपका नया वर्ष मंगलमय हो।

डॉ. आर के गौतम
प्राचार्य, स्वामी द्वारकादास कला एवं वाणिज्य
महाविद्यालय, ढीमरखेड़

मैं आपके मंत्रालय द्वारा प्रकाशित मासिक प्रत्रिका ''अक्षय ऊर्जा'' हिन्दी में नियमित रूप से प्राप्त करना चाहता हूँ। इसके अलावा नवीन एवं नवीकरणीय ऊर्जा से संबंधित रिर्पोट (हिन्दी में) भी प्राप्त करना चाहता हूँ। अतः आपसे प्रार्थना है कि उपरोक्त सूचना साहित्य हिन्दी में भेज कर कृतार्थ करें और आवश्यक कार्यवाही से भी अवगत कराएं। अन्य शुभकामनाओं सहित!

धन्यवाद।

जसवंत सिंह माथुरी,
कला समीक्षक

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja will make every effort to make this newsletter highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in terms of content and presentation. **Editor: Akshay Urja**

Contents April 2012

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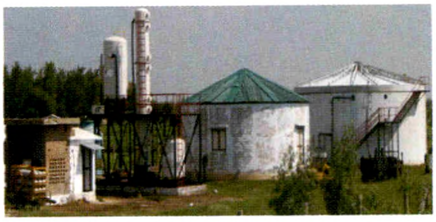
A detailed study of the use and applicability of geothermal energy in the Indian context.

Power from a biogas plant in the residential school which has helped an institute to meet their needs in everyday life from cooking to running various machines.



Today's fast world is overly dependent on energy to fulfill requirements related to daily life. Compressed biogas comes as an efficient and cost effective method to meet this need.

Kolkata Gets a New Renewable Energy College

Kolkata can now boast of a renewable energy college that opened in the city in January 2012. The college is located off EM Bypass at Madurdaha. Students passing out from the college receive a diploma jointly certified by the Indira Gandhi National Open University (IGNOU) and the Technical Education Department of the State of Queensland, Australia. The college is the brainchild of renewable energy expert and Ashden award winner S P Gon Chaudhuri, who is presently Advisor to the state government's power department. "Students who pass out from this college will be recognised as renewable energy engineers," stated Gon Chaudhuri, who will head the college as its chairman.

www.energynext.in
27 December 2011

India, China Focussing on Renewable Energy Sources: WEF

India, China and South Korea are increasingly focussing on renewable energy sources, including wind and solar, as potential growth sectors for their economies, as per the World Economic Forum report released on 9 March 2012.

However, the report, Energy for Economic Growth - Energy Vision Update 2012, which provides a framework for understanding the larger economic role of the energy industry, added that the higher costs of these technologies create trade-offs that must be considered.

"Energy prices will always be volatile and thus represent a challenge for long-term economic planning," said Kenneth Rogoff and Thomas D Cabot, Professor of Public Policy and Professor of Economics, Harvard University. "The question is how to make this volatility less economically damaging," added Rogoff, who is part of the WEF advisory board. While multiplier effects for solar and wind energy were lower during operation, their contribution during the construction phase reached as high as 3.3 indirect jobs per energy job. "The energy industry is unique in its economic importance and has the potential to be a tremendous catalyst for job creation and sustainable growth without harming the sector's overall performance," said Chairman Daniel Yergin of IHS CERA, which has partnered in the preparation of the WEF report. The energy industry thus has the ability to generate significant contributions to GDP growth, the report said.

www.renewsindia.com
9 March 2012

Tamil Nadu to add 3,000 MW Solar Energy

Tamil Nadu has set a target to add 3,000 MW of solar energy as part of its solar mission programme by 2015-16. This is more than 33 per cent of India's target. The State Government is also planning to bring in a new policy for solar energy was disclosed by Natham R Viswanathan, Minister for Electricity and Prohibition and Excise in a recent conference organised by Tamil Nadu Energy Development Agency (TEDA). The Minister also added, "We need financial assistance to boost the renewable energy sector so as to address the power deficit." With this move, Tamil Nadu, according to him, would become a power surplus state by 2015-16. The State is facing a shortage of around 4,000 MW at present.

www.indianpowersector.com
8 March 2012.

REC Raising New €100 mn Loan

The Rural Electrification Corp. Ltd. (REC) is set to raise €100 million (Rs. 656 crore) from Germany-based KfW Bankengruppe for financing renewable energy projects in India at concessional interest rates. The REC has sanctioned loans worth Rs. 50,000 crore and disbursed loans estimated at around Rs. 25,000 crore in the current fiscal (2012-13). "The REC is borrowing from a foreign lender to tide over the acute shortage of funds facing power companies in India. Also, funds raised from global markets are cheaper, given the high interest rates in India" said R Sharma, CMD, REC. The REC and the Power Finance Corporation of

India which accounts for 60 per cent of lending to the power sector, have formulated guidelines for lending to renewable energy projects for the first time. India's power sector, already struggling with fund shortfalls, will need an investment of $400 billion during the 12th Five-Year Plan (2012-17).

www.livemint.com
14 March 2012

Railways Plans to Turn a Green Leaf through Renewable Energy

In an attempt to become environment friendly, the Indian Railways plans to set up renewable energy generation capacities - such as wind power, solar energy and bio-diesel plants - for its own use, railway Minister Dinesh Trivedi said in his budget speech on 14 March 2012 .

The renewable energy plans of the railways include setting up 72 MW wind power plants in Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal. This will also help the carrier to avail fiscal incentives, including tax breaks for 10 years and depreciation benefits, besides a chance to earn carbon credits. In addition, the railways will also install bio-toilets developed by the Defence Research and Development Organisation in 2,500 coaches in the next fiscal year to stem environmental degradation and corrosion of tracks due to human waste. The railways also plans to use solar energy to run 200 stations and provide lighting systems at 1,000 manned, level crossing gates. As part of its green energy initiative, it plans to run a train on pilot basis, in north Bengal, with low-emission diesel locomotive and bio-toilets. There are also plans to commission two bio-diesel plants in 2012-13 at Raipur in Chhattisgarh and Tondiarpet in Tamil Nadu.

www.sustainabilityoutlook.in
15 March 2012

India's Wind Energy Potential is Over 2,000 GW

According to a recent study by the US based Lawrence Berkeley National Laboratory, the real wind energy potential of India is well over 2 million MW. After reassessing the land that can be used for wind power development, so as to take into account previously excluded lands, Lawrence Berkeley concluded that the true potential of wind energy in India is between "20 and 30 times higher than the current official estimate of 102 GW." It was previously thought that only 2 per cent of land in windy areas could be used for putting up wind power projects. The study looked at wind speeds at heights of 80 m, 100 m and 120 m and has found that nearly 1,629 sq km of area is available for setting up wind turbines at a height of 80 m, with a plant load factor (PLF) of more than 25 per cent. The cost of wind power is now comparable to that from imported coal and natural gas based plants, and wind can play a significant role in addressing energy security and environmental concerns in a cost effective manner.

www.infraline.com
27 March 2012

Committee on Renewable Energy Set Up

The government has set up a committee to suggest legislative and policy changes to speed up capacity addition from renewable power sources like wind, biomass and the Sun. The committee will be headed by a senior official from the Power Ministry and include representatives from the Ministry of New and Renewable Energy, power distribution companies (discoms), Central Electricity Regulatory Commission, electricity regulatory commissions from renewable resource-rich states like Tamil Nadu, Gujarat and Rajasthan and power project funding agencies, like Power Finance Corporation (PFC) and Rural Electrification Corporation (REC).

The committee's terms of reference include suggesting legislative changes to make it binding for discoms to comply with the renewable purchase obligation (RPO). It is also mandated to outline measures to penalise discoms in case of violation of the obligation. The panel also has the mandate to suggest amendments to the Electricity Act 2003 to empower the regulators to frame innovative market instruments like renewable energy certificates (REC) to facilitate development of the renewable power market.

www.financialexpress.com
28 March 2012

Fedders Lloyd to Expand Wind Energy Equipments Facility at Bharuch

The Lloyd Group owned Fedders Lloyd plans to invest Rs 200 crore for expanding its newly built manufacturing facility for wind turbine towers, heavy precision fabrication and machining facility in Bharuch district, Gujarat. The group commissioned the first phase of the unit and it has already acquired land for the phased expansion.

Commenting on the project commissioning, Fedders Lloyd CMD Brij Raj Punj said that renewable energy represents the next big frontier in the technology industry and the new facility is a testament to Fedders Lloyd's commitment to contribute towards India's growing energy revolution in India.

The Union Minister for New and Renewable Energy, Farooq Abdullah and Gujarat Chief Minister Narendra Modi inaugurated the new facility of Fedders Lloyd on 13 April 2012. The plant is capable of manufacturing wind turbine powers up to 3 MW and heavy precision fabrication of components up to 80 tonne. Established in 1957, Fedders Lloyd is engaged in executing turnkey projects in the areas of energy, infrastructure and climatic control equipment with manufacturing facilities at Noida, Sikandrabad and now Bharuch.

www.economictimes.indiatimes.com
15 April 2012

Government Extends Popular Accelerated Depreciation Scheme for Wind Power Producers

The government has decided to extend the popular accelerated depreciation incentive for wind power producers beyond 31 March this year, when it was due to be terminated, as the alternative generation based schemes have not found enough takers. Power producers can opt for either of these incentive schemes, and since as many as 70 per cent have opted for accelerated depreciation, an overwhelming majority of the companies have been lobbying for extension of this scheme which provides subsidies for setting up wind-generated power plants.

At the same time, the generation-based incentives, introduced in 2009, have fallen way short of the government's target of 4,000 MW, yielding just 1,500 MW so far. Officials and industry persons reacted to the news positively. " We have asked the Finance Ministry to let accelerated depreciation continue as it will help us achieve the earlier missed targets" said GB Pradhan, Secretary, Ministry of New and Renewable Energy. "Accelerated depreciation has been a major support to industries looking for captive power capacity for energy security and to freeze power costs, making the sector even more globally competitive," said the official spokesperson of Suzlon, the leader in the domestic market. V Subramaniam, Secretary General of Indian Wind Energy Association, said the extension of the scheme will prove to be a boon to companies. 'This will help attract more orders', said Subramaniam, calculating an investment of Rs 15,000 cr at an estimated installation of 3,000 MW of wind-generated power this year.

www.article.win.com
27 March 2012

Hybrid Guide Lights for Fishermen at Night

The Fisheries Department has decided to install 10 hybrid guide lights in the fishing hamlets of coastal Tamil Nadu to enable fishermen to reach their destinations at night, with ease.

Fishermen set out for sail, keeping major lighthouses as an identification mark. Due to lack of proper lighting system and high winds, they often land a few kilometres away from their destinations. Hence, they sought the help of Fisheries Department.

Based on reports of the cost effective hybrid system installed at Tamil Nadu Development Corporation's Raindrop Boat House in Mudaliarkuppam, three years ago, the officials of the Fisheries Department approached Coimbatore-based Viviann Electric. The firm developed three devices which have been functioning at Panaiyur Chinnakuppam in

Kancheepuram district, Tranquebar near Nagapattinam and Somanathan Pattinam in Thanjavur district since January 2011. The device uses both solar and wind energy. These solar and wind hybrid guide lights comprising LEDs with 40 watts capacity and 500 watts wind generator, are visible several kilometres from the shore. Sources stated that Coast Guard officials too have started using them as a landmark.

www.thehindu.com
26 March 2012

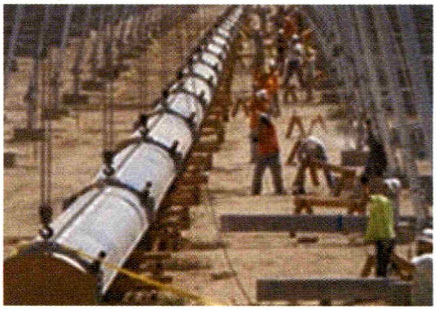
Rice Husk, Solar Energy to Solve Power Issues

If all goes well, rice husk and solar power - two very unlikely partners -will together provide rural India with a twin solution to its problems of power shortage and lack of storage for agriculture produce. What's more, the evolving system promises zero emission of pollutants as well.

The government's Solar Energy Centre, New Delhi, has managed to make use of rice husk and solar power, both of which are being wasted at present, to come up with a technological marvel that would prevent wastage of food grains in rural India. The rice husk is burnt to produce enough energy for powering a turbine and producing electricity. As of now, there are 60 mini-rice husk powered electricity plants that light 25,000 households in different parts of the country. The emission from the rice husk plants is coupled with energy generated by solar thermal plates to run a cold storage with a capacity of 15 tonnes. The project, undertaken in collaboration with Thermax and The Energy and Resources Institute, is past the experiment stage and is set to be rolled out in rural India.

www.hindustantimes.com
29 March 2012

India to be a Global Sourcing Hub for Solar Projects



AREVA Solar, the US-headquartered renewable energy subsidiary of the French nuclear energy group, AREVA, has an ambitious plan to tap the growing solar market in India as a technology provider. William D Gallo, president and chief executive officer, has promised to make India a hub to source solar technology for their international operations. Gallo informed that India enjoys 250 to 300 sunny days a year and is, therefore, a potentially privileged location for solar power plant projects. The company has also been awarded a contract by Reliance Power to set up a 250 MW project in Rajasthan.

The AREVA group aims to position itself as a strategic player in the development of renewable energy sources. India will be a global sourcing hub for solar projects, remarked Gallo.

He said that as a technology provider, AREVA will source most of the steel and glass from the domestic market, and has plans to set up a large number of plants in India. Besides, there is availability of the skills required for assembling and for this they will rope in local contractors. Gallo added that the Concentrated Solar Power (CSP) systems used by AREVA are suited for a variety of power plants from 50 MW to several hundred MW, as well as a diverse range of industrial steam applications and that they are cost effective, land conservative and water efficient.

www.fastindia.in
16 April 2012

India's Installed Power Generation Capacity Crosses 2 Lakh MW Mark

India's installed total power generation capacity has crossed the 2 lakh MW mark with the commissioning of a 660 MW unit of a power plant in Jhajjar in Haryana. The total installed capacity in the country has now reached 2,00,287 MW, per an official press release. This includes 1,32,013 MW capacity in the thermal sector, 38,991 MW in the hydro sector, 4,780 MW in the nuclear sector and 24,503 MW in the renewable energy sector. At the end of the 11th Plan, i.e. on 31 March 2012 the total installed capacity stood at 1,99,627 MW. There was a capacity addition of 54,964 MW in the 11th Plan period, up 159 per cent over the 10th Plan period when 21,180 MW capacity was added. During the Ninth Plan, the capacity addition stood at 19,010 MW. In 2011-12, a capacity of 20,501 MW was added, out of which 5,482 MW was added in March 2012 alone, the release added.

www.netindian.in
14 April 2012

Germany Could Become Storage Technology Hotspot

During the International Summit for the Storage of Renewable Energy, Germany's Environment Minister, Norbert Röttgen spoke about market incentives for storage systems. These, he said, are important for the development of market applications. He went on to tell the audience of over 300 experts, from 28 countries, that the immediate task is to develop renewable energy and energy efficiency technologies, and integrate them into the market. Eicke Weber, spokesman for the Fraunhofer Energy Alliance and head of the Fraunhofer Institute for Solare Energy Systems (ISE), during his presentation asserted, "Energy storage is part of a paradigm shift in renewable energy adoption and usage. Storage at its basic is about being able to use harvested renewable energy produced at a very low cost exactly when we need it." He said that there is a wide range of storage technologies, which will create an important role for energy storage systems in Germany's future. According to Weber, the country is particularly well-positioned to become a hotspot for energy storage technologies, due to plans to phase out nuclear power and its clear goals on continuing the expansion of the deployment of fluctuating renewable energy.

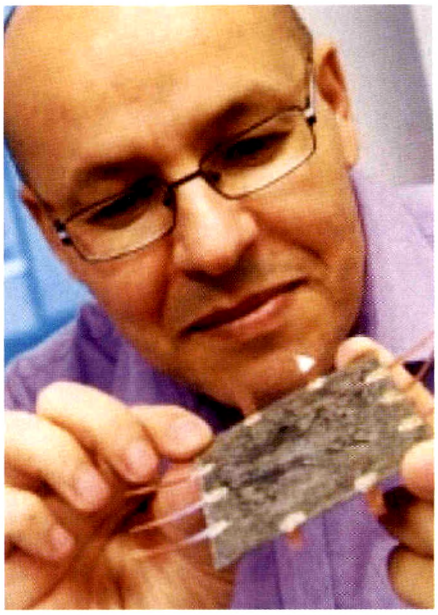
www.pv-magazine.com
13 March 2012

Nanotrees Harvest the Sun's Energy to Turn Water Into Hydrogen Fuel

Electrical engineers at the University of California, San Diego are building a forest of tiny nanowire trees in order to cleanly capture solar energy without using fossil fuels and harvest it for hydrogen fuel generation. Reporting in the journal, Nanoscale, the team said nanowires, which are made from abundant natural materials like silicon and zinc oxide, also offer a cheap way to deliver hydrogen fuel on a mass scale. The trees' vertical structure and branches are key to capturing the maximum amount of solar energy, according to Deli Wang, professor in the Department of Electrical and Computer Engineering at the UC San Diego Jacobs School of Engineering. In the long run, what Wang's team is aiming for is even bigger: artificial photosynthesis. In photosynthesis, as plants absorb sunlight they also collect carbon dioxide (CO_2) and water from the atmosphere to create carbohydrates to fuel their own growth. Wang's team hopes to mimic this process to capture CO_2 from the atmosphere, reducing carbon emissions and converting it into hydrocarbon fuel.

www.sciencedaily.com
7 March 2012

Smart Paint Could Revolutionise Structural Safety of Bridges, Mines and More



An innovative low-cost smart paint that can detect microscopic faults in wind turbines, mines and bridges before structural damage occurs is being developed by researchers at the University of Strathclyde in Glasgow.

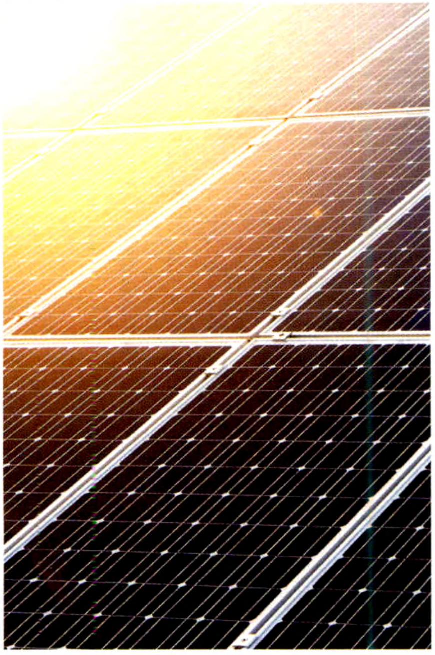
The environment-friendly paint uses nanotechnology to detect movement in large structures, and could shape the future of safety monitoring. Traditional methods of assessing large structures are complex, time consuming and use expensive instrumentation, with costs spiraling into millions each year.

However, the smart paint costs just a fraction of the cost and can be simply sprayed onto any surface, with electrodes attached to detect structural damage long before failure occurs. Dr Mohamed Saafi, of the University's Department of Civil Engineering, said: "The development of this smart paint technology could have far-reaching implications for the way we monitor the safety of large structures all over the world.

"There are no limitations as to where it could be used and the low-cost nature gives it a significant advantage over the current options available in the industry. The process of producing and applying the paint also gives it an advantage as no expertise is required and monitoring itself is straightforward, he said." The paint is formed using a recycled waste product known as fly ash and highly aligned carbon nanotubes. When mixed, it has a cement-like property which makes it particularly useful in harsh environments.

www.esciencenews.com
30 January 2012

Abu Dhabi Bets on Anti-Dust Solar Panels



Abu Dhabi is teaming up with a global electronics company to develop better coatings for solar panels to make them cheaper and easier to keep clean in desert conditions. The Middle East and North Africa (MENA) region stands to benefit from concentrated solar power (CSP) – a technology that uses lenses or mirrors to focus large amounts of sunlight onto a small area. This light is converted to heat, which generates electricity. But harsh desert conditions in parts of the MENA region generate large amounts of airborne dust which collects on the solar panels used in CSP systems, reducing their efficiency. They need regular cleaning, which consumes large amounts of water.

Now, the Masdar Institute of Science and Technology says it will work with Siemens AG to develop coatings using water-repellent materials, commonly used to manage oil spills. These materials force water droplets to form beads that then trap dust, meaning that less water would be needed to keep the panels clean.

Matteo Chiesa, Associate Professor of Mechanical Engineering at the Masdar Institute said that the team is also developing a modelling tool that will incorporate weather data, to predict how often the panels will need cleaning. He also added that the field tests are underway to test the coating and predictive tool, and the adapted solar panels could reach the market within five years.

www.scidev.net
5 March 2012

Total Green Electricity Generation for Scotland

Scotland will be able to generate all its domestic electricity using renewable methods by 2020, the government has confirmed. However, it will be a challenge to reach the target and green energy generation will need to be supported by at least 2.5 GW from thermal power units that will be increasing their carbon capture and storage rates. The government also aims to completely remove carbon from electricity generation by 2030, under plans outlined in the Electricity Generation Policy Statement (EGPS), which has just been released.

Fergus Ewing, Scotland's Energy Minister, says, "We know there is doubt and scepticism about our 100 per cent renewables target, and the financial and engineering challenges required to meet it. But we will meet these challenges. I want to debate, engage and co-operate with every knowledgeable, interested and concerned party to ensure we achieve our goals." The plans mean there will be no need to build any new nuclear power stations in Scotland. By 2020, the government aims to support local and community ownership of at least 500 MW of renewable electricity and heat energy. It also plans to reduce final energy consumption in Scotland by 12 per cent and complete full carbon capture and storage at power stations from 2025-2030. In the related 'The Power of Scotland Secured' document, green campaigners 'Friends of the Earth' commissioned a report saying that by 2030 renewable methods could provide enough electricity for all of Scotland's energy needs plus 85 per cent extra for export.

www.earthtimes.org
6 March 2012

Hydrogen Energy and Fuel Cell Technologies

Recent Developments and Future Prospects in India

Energy security is a major challenge that needs imaginative and innovative solutions for a country like India. Therefore, options for diversification of fuels and energy sources need to be pursued vigorously to enhance the economic growth rate for socio-economic development.

M. R. Nouni

Fuel cell bus developed by TATA motors

The growing concern about depleting oil reserves, harmful effects of greenhouse gas emissions and the necessity to reduce emissions from power plants and vehicles are some of the key factors encouraging the development of new and renewable energy technologies. Hydrogen: the zero carbon fuel, excels in comparison to other fuels including bio-fuels, with regard to first the decrease and then the elimination of the effect of climate change. Thus, hydrogen is a clean energy carrier with potential to replace liquid and gaseous fossil fuels in the coming decades. In recent years, notable progress has been made globally for the development and demonstration of hydrogen energy and fuel cell technologies. Hydrogen can store and deliver usable energy, but it doesn't exist by itself in nature. It must be produced from compounds that contain it - using available resources - natural gas, coal and nuclear; biomass and other renewables including solar, wind, hydro-electric, or geothermal energy. This diversity of being able to use diverse energy sources makes hydrogen a promising energy carrier and important from the energy security view point. Hydrogen is high in energy content as it contains 120.7 MJ/kg, which is the highest for any known fuel. However, its energy content on volume basis is rather low. This poses challenges with regard to its storage for civilian applications, when compared to storage of liquid fossil fuels.

With primary emphasis on energy security and environment improvement, various Research, Development and Demonstration (RD&D) activities on different aspects of hydrogen energy that includes hydrogen production, its storage and applications for motive power and power generation through internal combustion engine and fuel cell based systems, have been pursued by academic institutions, Council for Scientific and Industrial Research (CSIR) laboratories, industry etc. with the support of Government of India, for more than two decades. As a result, laboratory scale prototypes have been developed and some of them include: (a) bio-hydrogen production using distillery wastes; (b) Proton Exchange Membrane (PEM) based electrolysers for hydrogen production through splitting of water and water-methanol mixture; (c) inter-metallic hydride with storage capacity upto 2.42 wt per cent; (d) liquid organic hydrides for hydrogen storage with storage capacity of about 6 wt per cent ; (e) methanol reformer for production of hydrogen, which can be used in PEM fuel cells; (f) hydrogen catalytic combustion cookers; (g) hydrogen fuelled motor-cycles and three wheelers with hydrogen storage in metal hydrides; (h) hydrogen fuelled three wheelers with hydrogen storage in high pressure composite cylinders; (i) hydrogen fuelled internal combustion engine for stationary power generation; (j) phosphoric acid fuel cells with stacks up to 25 kW capacity; (k) PEM fuel cells with stacks up to 5 kW capacity; (l) UPS system based on PEM fuel cell; (m) fuel cell battery hybrid van; (n) hydrogen blended CNG (H-CNG) fuelled vehicles; etc. Use and applications of hydrogen are in the early demonstration stages in the country both for transport and for stationary power generation.

National Hydrogen Energy Road Map

With a view to accelerate the development of hydrogen energy sector in the country, a National Hydrogen Energy Board, which included all the stakeholders, was constituted in 2003. They created a National Hydrogen Energy Road Map that provides the broad pathway to be followed for development and introduction of hydrogen energy technologies in the country. For achieving the overall growth of the entire hydrogen energy sector, the Road Map suggested ambitious targets for transport sector and power generation for the period up to 2020. It also emphasised the need for taking up a wide ranging R&D programme in the country including eight projects in mission mode relating to (a) clean coal gasification technologies for hydrogen production; (b) hydrogen production through biological sources; (c) hydrogen production through renewable energy sources; (d) hydrogen production through nuclear thermo-chemical water splitting method; (e) hydrogen storage in hydrides; (f) hydrogen storage in carbon nano-structures; (g) development of internal combustion (IC) engine for hydrogen fuel; and (h) development of PEM and solid oxide fuel cell (SOFC) technologies.

> **Hydrogen can be produced using locally available resources including natural gas, coal and nuclear, biomass and other renewables including solar, wind, hydro-electric or geothermal energy.**

Efforts Made during the 11th Plan

Hydrogen energy and fuel cell activities in the country received an impetus after the acceptance of the National Hydrogen Energy Road Map in 2006. From 2006-07 onwards a total of 54 new RD&D projects, of which 38 projects in the area of hydrogen, its storage and applications and 16 projects related to different fuel cell technologies are being supported by the Ministry of New and Renewable Energy (MNRE). The extent of the support provided to hydrogen energy and fuel cell activities is clear from the fact that out of 169 new RD&D projects supported by the MNRE during the 11th Plan Period (2007-08 to 2011-12), 44 projects (26 per cent) were related to hydrogen energy and fuel cells. In terms of the total financial support provided by the MNRE during the 11th Plan Period, hydrogen energy and fuel cell projects were provided with a budget of about Rs. 118 crore out of the total RD&D support of about Rs. 507 crore.

Hydrogen Production

It is pertinent to note that a large number of projects concerning hydrogen production, have been sanctioned during the 11th Plan and are shown in Fig. 1. Further, for meeting the requirement of hydrogen up to 2020, the National Hydrogen Energy Road Map had suggested

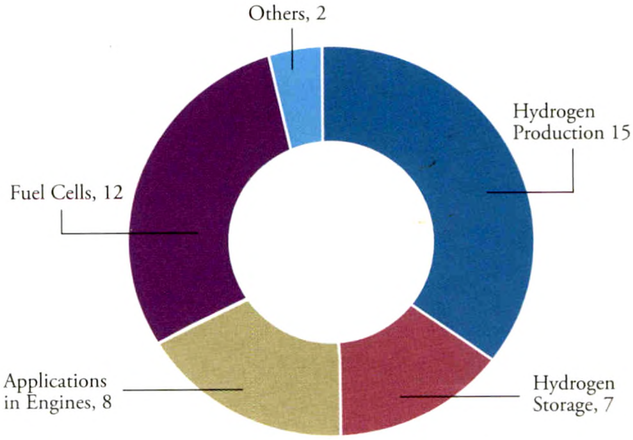


Fig 1. Sector wise distribution of sanctioned RD&D Projects related to Hydrogen Energy and Fuel Cells during the 11th Plan

> **The National Hydrogen Energy Road Map provides the broad pathway to be followed for development and introduction of hydrogen energy technologies in the country.**

different processes as shown in Fig 2. In order to meet the immediate requirement of hydrogen for transport and power generation applications, it was suggested to tap by-product / spare hydrogen available in industries like chlor-alkali industries, fertiliser plants and petroleum refineries. A study conducted by the University of Petroleum and Energy Studies estimated a theoretical surplus of 0.0313 MMT, out of a total hydrogen generation capacity of 0.0732 MMT from chlor-alkali units during 2007-08. No surplus hydrogen is available in petroleum refineries and fertiliser plants. As per information compiled by the Alkali-Manufacturers Association of India, hydrogen produced by 37 chlor-alkali units in India was about 666.29 million N cu m (0.0598 MMT) during 2010-11. About 86.39 per cent of it was being utilised for production of hydrochloric acid, as fuel for captive use sold after bottling it, in downstream units and other applications. Therefore, about 0.0081 MMT of surplus hydrogen was available from chlor-alkali units during 20101-11. However, it seems that the amount of surplus hydrogen from chlor-alkali units is progressively reducing after analysing the hydrogen consumption pattern for the years 2008-09, 2009-10 and 2010-11.

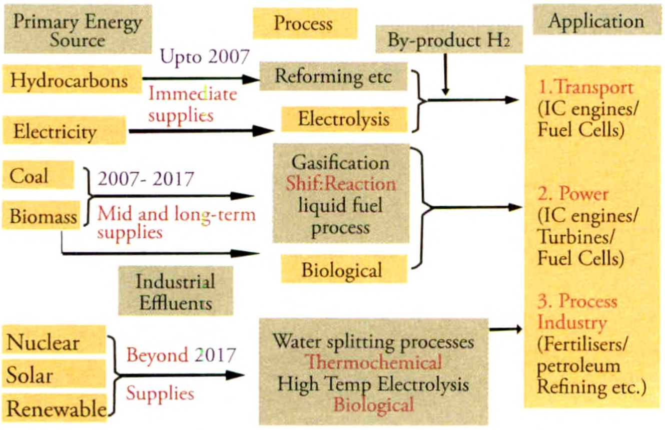


Fig 2. Hydrogen supply processes suggested in the National Hydrogen Road Map

A demonstration project for on-site hydrogen production using alkaline electrolyser of 5 N cu m/hr capacity, blending it with compressed natural gas and dispensing of H-CNG was commissioned at Dwarka in New Delhi by the Indian Oil Corporation Limited (IOCL) in March, 2009. A similar unit was installed by IOCL in its R&D Centre at Faridabad in 2005. These facilities are being currently used for dispensing H-CNG fuel in some demonstration vehicles. The Electrical Research and Development Association (ERDA), Vadodara has developed a prototype demonstration project for wind hydrogen based stand-alone electrical generation. Under this project, 2x5 kW small wind turbines have been used to meet the electrical energy requirement of a load either directly through a battery bank or through a gen-set, which used hydrogen as a fuel produced by an electrolyser operated by direct current (DC) drawn from the battery bank. With a view to generate hydrogen from solar energy, a hydrogen production and dispensing facility is scheduled to be set up at the Solar Energy Centre (SEC), Gwalpahari using PV generated electricity for operating an electrolyser. The demonstration project, being implemented by the University of Petroleum and Energy Studies (UPES), Dehradun is likely to be commissioned by 2013-14. For hydrogen production through gasification of biomass, one project each is being implemented by the Indian Institute of Science (IISc), Bangalore and the National Institute of Technology (NIT), Rourkela. The IISc is working on the development of the oxy-steam gasification unit using an open top downdraft gasification system for hydrogen production rate of about 0.1 kg/kg biomass at various steam-to-biomass ratios. The NIT, Rourkela will be developing a bench scale fluidised bed gasifier of 5 kW capacity for hydrogen production rate of about 0.09 kg/kg of feed stock.

A pilot plant of 800 litres capacity for bio-hydrogen production was installed at Indian Institute of Technology (IIT) Kharagpur under a project that concluded in 2007. Hydrogen yield was observed to be 5.5 moles of hydrogen per mole of sucrose after 25 hours of fermentation, which amounted to about 2.4 cu m of hydrogen production per day from the reactor (the average hydrogen production is in the range of 3-5 volumes per day per volume of the reactor). In a mission mode project, under implementation from 2009 to 2014, IIT Kharagpur in association with Allahabad University, Banaras Hindu University (BHU), Indian Institute of Chemical Technology (IICT) Hyderabad, Jawaharlal Nehru Technological University (JNTUH) Hyderabad, and The Energy Research Institute (TERI), New Delhi would be designating, developing and installing three 10 cu m capacity pilot demonstration plants with hydrogen generation capacity of 30,000 to 50,000 litres per day. This project would aim at making bio-hydrogen production commercially viable by way of selection of suitable organic waste as substrate; development of suitable consortia for the process; use of thermophiles to avoid the sterilisation of the waste materials; and development of an integrated (two stage fermentation) process.

The IICT has undertaken work relating to catalyst development and bench scale reactor development for hydrogen production studies from biomass derived glycerol during 2008-11. The bench scale reactor is being scaled up for the development of a pilot demonstration plant of 2 N cu m/hr capacity of hydrogen production by IICT. The Central Institute of Mining and Fuel Research (CIMFR), Dhanbad developing a novel process for production of hydrogen from renewable and fossil fuel based liquid and gaseous hydrocarbons, by the non-thermal plasma reformation technique.

The Centre for Materials for Electronics Technology (C-MET), Pune and IICT are working on developing processes for decomposition of hydrogen sulphide for production of hydrogen by photo-catalytic and non-thermal plasma assisted methods respectively. For splitting water using solar energy directly, which is dubbed as the ultimate and sustainable method for hydrogen production, Institute of Minerals and Materials Technology (IMMT), Bhubaneswar; IICT and Yogi Vemana University, Kadapa are some of the institutions that are engaged in carrying out R&D work in India.

Hydrogen Storage

Hydrogen storage remains a major problem for the development and viability of hydrogen-fuelled vehicles and is considered by many to be the most technologically challenging aspect for achieving a hydrogen-based economy. As per the experts, on-board hydrogen storage capacity in the range of approximately 5–13 kg is required to enable a driving range of about 500 kms for typical automotive vehicles using fuel cell power plants. Presently hydrogen can be stored in three forms; gaseous, liquid or as a solid combined with a metal hydride. The most suitable storage method is dependent upon safety aspects, environmental issues, economic criteria and the end-use of hydrogen.

The R&D work carried out so far in the country has been focussed on metal hydrides, inter-metallic hydrides, complex hydrides, liquid organic hydrides etc. While three R&D projects were completed during 11th Plan (Fig 3), seven new R&D projects were sanctioned during this period in the area of hydrogen storage (Fig 1). The completed projects were related to synthesis and evaluation of complex hydrides; development of liquid organic hydrides; and theoretical investigation on 'likely to be favourable factors' of helical carbon nano-tubes for enhanced hydrogen absorption undertaken by IIT, Mumbai; National Environmental Engineering Institute (NEERI), Nagpur and Thiagarajar College of Engineering, Madurai, respectively. The NEERI identified and tested a catalyst for dehydrogenation of cyclohexane and methylcyclohexane. Hydrogen storage capacity for the process was found to be 6.1- 6.8 wt per cent.

With a view to achieve about 5 wt per cent storage capacity in hydrides and carbon materials with cycle life of more than 1000, one mission mode project each is being implemented by BHU, Varanasi and IIT Madras, Chennai. Non Ferrous Materials Technology Development Centre, Hyderabad and NIT, Tiruchirappalli are working on different aspects of magnesium hydride material. The IIT,

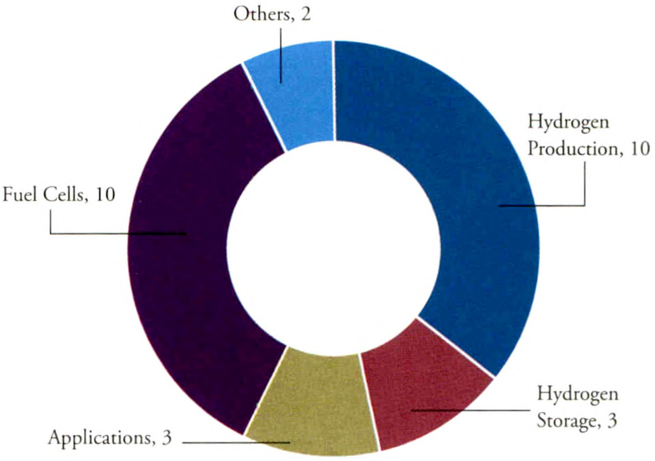


Fig 3. Sector wise distribution of RD&D Projects related to Hydrogen Energy and Fuel Cells completed during the 11th Plan

Fig 4. Hydrogen fuelled three wheeler

> **Efforts related to use of hydrogen as fuel have been mainly focused on development of internal combustion engines by modifying petrol, diesel and gaseous engines to operate with hydrogen.**

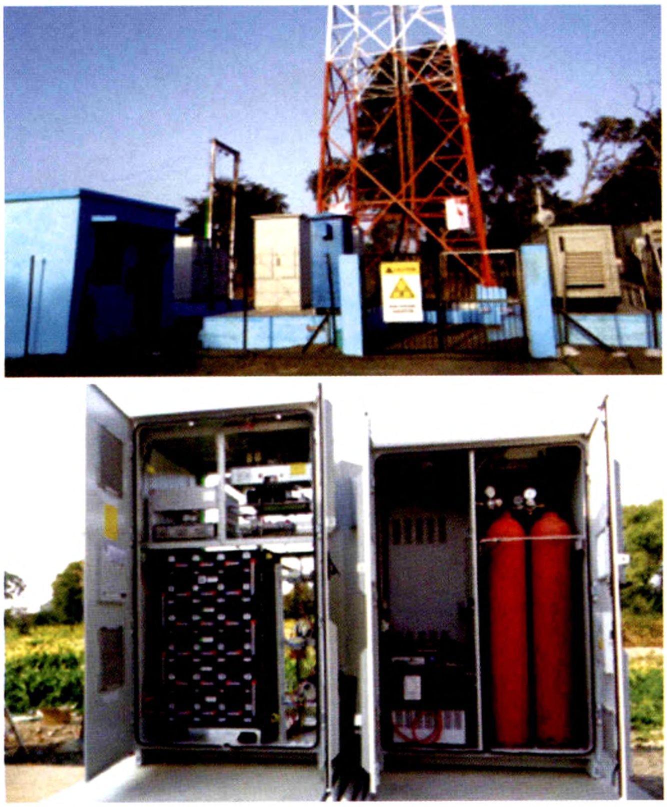


Fig 5. Fuel cell system

Guwahati is engaged in development of a metal hydride based hydrogen storage device.

Use of Hydrogen in Engines and for Thermal Applications

Efforts related to use of hydrogen as fuel have been mainly focussed on development of internal combustion engines by modifying petrol, diesel and gaseous engines to operate with hydrogen. To begin with, existing spark ignited engines were modified to operate with hydrogen as a fuel. Prototypes of such engines are small single cylinder engines. A single cylinder four stroke, spark ignited, air cooled 5 hp engine was modified to operate with hydrogen and integrated with a 2.5 kVA alternator by IIT, Delhi for power generation for stationary applications. The learnings from this effort helped IIT, Delhi develop a hydrogen fuelled engine for a three wheeler in association with Mahindra and Mahindra (M&M). In addition, petrol driven motorcycles and three wheelers have also been modified to operate with hydrogen as a fuel by BHU, Varanasi.

Blending of hydrogen with CNG was considered to be the best strategy for not only introduction of hydrogen in some form in vehicles under Indian conditions but also for gaining experience about production, storage, dispensing and application of hydrogen as the infrastructure for CNG was already available in some parts of the country. On acceptance of the National Hydrogen Road Map, one of the earliest projects taken up for implementation related to the use of hydrogen (up to 30 per cent) as fuel, blended with CNG in an internal combustion engine. Under this project, being implemented by the Society of Indian Automobile Manufacturers (SIAM) and R&D Centre of IOCL, two three wheelers, two cars, two mini buses and one cargo vehicle have been developed by five automobile companies i.e. Ashok Leyland Limited, Bajaj Auto Limited, M&M, Tata Motors and Volvo Eicher. Based on the performance and emission tests undertaken by IOCL, it was decided that blending of 18 per cent hydrogen by volume with CNG is the optimum blend to be used in the vehicles included in the project. Currently, these vehicles are undergoing field endurance testing (30,000 kms for three wheelers and 50,000 kms for other vehicles) between Faridabad and Dwarka, New Delhi as the facilities for supply of H-CNG exist at R&D Centre of IOCL at Faridabad and Dwarka, New Delhi. The project would be completed during 2012 and may pave the way for introduction of more H-CNG fuelled vehicles on Indian roads.

In order to study the impact of using hydrogen - diesel and hydrogen-straight vegetable oil (SVO) in dual fuel mode on performance and emissions of engines, two projects are under implementation. One project is being implemented by M&M in technical collaboration with Saskatchewan Research Council (SRC), Canada for development and demonstration of a sports utility vehicle using hydrogen along with diesel. Under another project, the University of Petroleum and Energy Studies (UPES) is developing a stationary engine for using hydrogen with SVO.

The M&M in association with the IIT, Delhi has developed 15 three wheelers under a project named 'DELHY-3W' which was supported by the United Nations Industrial Development Organisation (UNIDO) through the International Centre for Hydrogen Energy Technologies (ICHET), Istanbul, Turkey (Fig. 4). This project was supported in March, 2009 with IIT Delhi; M&M; Air Products / INOX Air Products; and India Trade Promotion Organisation (ITPO) as project partners.

Under this project, 15 hydrogen fuelled three wheelers are being demonstrated at New Delhi currently. Hydrogen is stored in a compressed gaseous form in composite cylinders. Limited field trials have shown that the hydrogen fuelled three wheelers are giving around 85 km per kg of hydrogen consumed. The facilities for transport, storage and dispensing of hydrogen has been provided and managed by the Air Products. Under another project, BHU Varanasi is engaged in development of about 10 hydrogen fuelled three wheelers with hydrogen storage in metal hydrides instead of in the gaseous form in a pressure vessel.

With a view to develop a multi-cylinder hydrogen fuelled engine that can be used in a bus, a mission mode project is under implementation by IIT, Delhi in association with M&M. The Annamalai University is working on lean limit extension for spark ignited direct injection engine through on-board non-thermal plasma conversion for hydrogen production. Also IIT, Kanpur is undertaking experimental investigations on combustion characteristics and emission reduction of laser fired hydrogen engine and is engaged in design and development of hydrogen gas burner for industrial applications.

Fuel Cell

The focus of R&D on fuel cells in India is on different types of fuel cells namely polymer electrolyte membrane fuel cell (PEMFC), phosphoric acid fuel cell (PAFC), direct methanol fuel cell (DMFC), direct ethanol fuel cell (DEFC), solid oxide fuel cell (SOFC) and molten carbonate fuel cell (MCFC). The emphasis of research has been on further improvements in fuel cell related processes, materials, components, sub-systems and fuel cell systems.

Ten projects related to different aspects of fuel cell technologies were concluded during the 11th Plan (Fig. 3). IIT, Madras developed methods to prepare composite membranes with desirable physico-chemical properties for possible commercial exploitation.

The R&D projects under implementation include the development of high performance DMFC by University of Kolkata; development of membranes for DMFC and PEMFC by Birla Institute of Technology and Science, Ranchi and Central Salt and Marine Chemical Institute (CSMCRI), Bhavnagar; and development of catalyst by Bengal Engineering Science University, Shibpur.

Industry Driven Initiatives

The Indian automobile industry and telecom tower operators too have made efforts to use hydrogen for powering automobiles using IC engine as well as fuel cell technology and also for providing back up power for telecom towers using fuel cells. In addition to M&M, Tata Motors has developed a fuel cell bus under a project supported by the Council of Scientific and Industrial Research (CSIR) and are planning to develop and demonstrate 10 fuel cell buses in the future. Idea cellular, a telecom tower operator has installed a PEMFC system to provide backup power to a telecom tower in Madhya Pradesh using hydrogen supplied from the nearby chlor-alkali unit (Fig 5). Such fuel cell systems would replace diesel generator sets, which in turn create environmental hazards.

> **Ten projects related to different aspects of fuel cell technologies were concluded during the 11th Plan period. Several R&D projects are under implementation with various universities of India.**

Capacity Building

With a view of capacity building in hydrogen energy sector and as suggested in the road map, a National Centre of Excellence for Hydrogen Energy and Fuel Cells may be set up in the country. For this purpose, a detailed project report (DPR) on setting up of National Hydrogen and Fuel Cell Centre at Gwalpahari, Gurgaon has been prepared.

Prospects for Future

There is an urgent need to set up hydrogen production cum dispensing stations at suitable locations, especially for making operation of hydrogen fuelled vehicles possible. We may also see hydrogen fuelled vehicles for public transport, including three wheelers and buses using either IC engine or fuel cell technologies on Indian roads. This is highly realistic as the Indian automobile industry has already taken a lead in this direction. However, this would require notifying H-CNG as well as hydrogen as automotive fuels. Fuel cell based systems may be used for power generation to provide backup power for telecom towers and stationary power generation by using surplus by-product hydrogen from chlor-alkali units.

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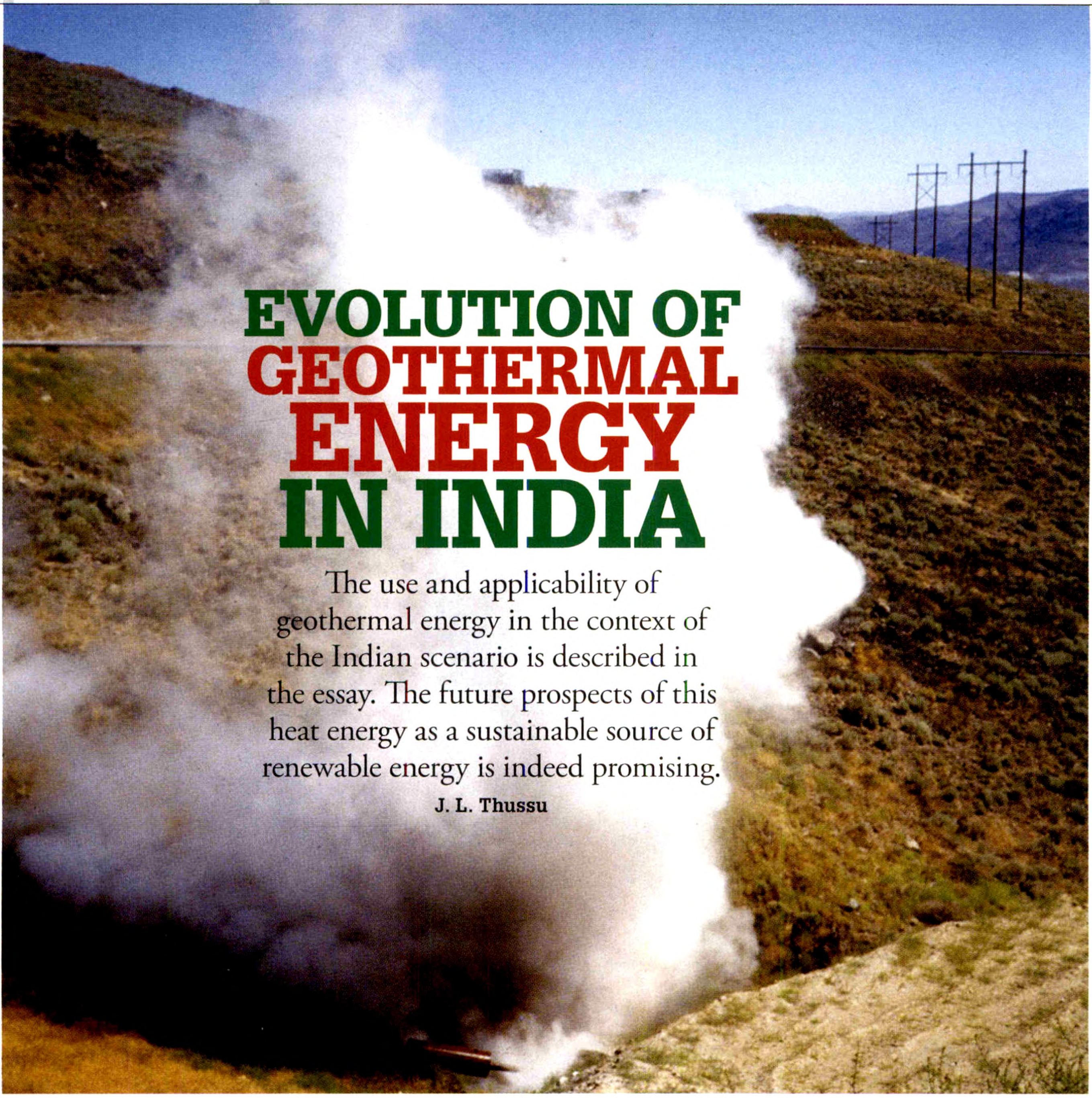

EVOLUTION OF GEOTHERMAL ENERGY IN INDIA

The use and applicability of geothermal energy in the context of the Indian scenario is described in the essay. The future prospects of this heat energy as a sustainable source of renewable energy is indeed promising.

J. L. Thussu

The earth is a reservoir of heat energy most of which is buried and is observed during episodes of volcanic eruption at the surface. It also manifests as hot springs, geysers and fumaroles. Thermal springs have been known to occur the world over for centuries. This resource did not attract attention for energy development probably because not enough was known about its potential till the early twentieth century. Conventional sources of energy like coal, oil and wood are non-renewable and are likely to deplete with the passage of time or depth of exploration becomes cost prohibitive. Also these resources create inherent problems of environment degradation and imbalance in ecology. The 'oil crisis' of the 1970s, resulting in low supplies of oil from producing countries led to the need for exploring alternative sources of energy for power production and other industrial uses. One of the resources was geothermal energy i.e. energy stored in the earth's crust.

Thermal springs have been a known phenomenon in India for centuries. People often visit these springs as a part of religious custom and belief considering the water to be 'God's Gift' to mankind and capable of miraculous healing of skin and other rheumatic ailments like arthritis. However, all thermal springs oozing at the surface need not necessarily have geothermal energy potential.

Schlagintweit (1862) and T. Oldham (1882), inventoried a total of 301 thermal springs in the Indian subcontinent. However these studies were mostly in reconnoitory state wherein documentation of the thermal springs, their surface temperature and assessing the medicinal qualities were recorded. At many places, like Badrinath and Gangotri in Uttarakhand; Sohna in Haryana; Rajgir in Bihar; Bakreshwar in West Bengal and Ganeshpuri in West Coast, Maharashtra, temples have been built on thermal springs and the water has been channelised for public use. Systematic efforts to explore geothermal energy resources commenced in 1973 with the launching of the Puga geothermal project in Ladakh, J&K and gradually the exploration work was extended to cover Chhumathang in Ladakh, Parbati valley, Himachal Pradesh.; Sohna, Haryana; West Coast, Maharashtra and Tattapani, Sarguja in Madhya Pradesh. To achieve the objectives of this endeavour, geological, geophysical, geochemical, and drilling activities were carried out under an integrated programme with the Geological Survey of India (GSI) as the lead agency and executed with the collaboration of many national agencies, viz. National Geophysical Research Institute (NGRI), Hyderabad, Atomic Minerals Division (AMD), New Delhi, Central Electricity Authority (CEA) and others.

Classification of Thermal Springs

About 300 thermal springs are known to occur in India. These thermal springs occur along the length and breadth of the country extending from Jammu and Kashmir in the north to Tamil Nadu (Kanya Kumari) in the south over a distance of about 5000 km, and from Gujarat in the west to Arunachal Pradesh in the east over a distance of 4000 km. The springs have been classified on the basis of their occurrence in specific geotectonic set ups and have been grouped under different geothermal provinces. However on the basis of enthalpy characteristics the geothermal systems in India can be classified into medium enthalpy (100-200°C) and low enthalpy (less than 100°C) geothermal systems.

Medium enthalpy geothermal systems are known to be associated with the following:

- Younger intrusive granites as in the Himalayas, viz. Puga-Chhumathang, Parbati, Beas and Satluj geothermal fields.
- Major tectonic features/lineaments such as the west coast areas of Maharashtra; along the Son-Narmada-Tapi lineament zone at Salbardi, Tapi - Satpura areas in Maharashtra, Tattapani in Madhya Pradesh and Rajgir-Monghyr in Bihar and Eastern Ghats of Orissa.
- Rift and grabens of Gondwana basins viz. Damodar, Godavari and Mahanadi.
- Quaternary and Tertiary sediments in a graben, viz Cambay basin off West Coast.

The thermal waters have been used for hatching poultry and for the growth of mushrooms in a hut, 500 sq m in area, by the Regional Research Laboratory, Jammu.

Low enthalpy geothermal systems are associated with the following:

- Tertiary tectonism and neotectonic activity - north Indian geothermal field viz. Sohna and Rajasthan.
- Shield area with localised abnormal heat flow which is normally very low - south Indian geothermal province.

The medium enthalpy waters could be utilised for either primary cycle power production (Puga geothermal system) or binary cycle power production using different types of freons (Tattapani geothermal system, Madhya Pradesh). The thermal water flowing at other areas, in Maharashtra, Himachal Pradesh, Haryana and Uttar Pradesh, although they fall in medium enthalpy geothermal systems, can be utilised for non-electrical applications only. The thermal water flowing from low enthalpy geothermal systems does not have much scope for harnessing of geothermal energy at present. Thermal water discharging from most of the geothermal systems in India, at present, have better scope for non-electric application.

Small scale experimegntal utilisation studies have been carried out at Puga, Chhumathang geothermal fields and at Manikaran in Parbati valley geothermal field. At present, the Puga geothermal field is the only field capable of producing either primary cycle electrical power or binary cycle power, that too on a very small scale. The thermal fluids have been utilised for heating of spaces, processing of borax and sulphur and extraction of salts. Its use in the extraction of the rare metal cesium is under experimentation. Poultry farming and green house cultivation are the other industrial applications for which geothermal energy has been used. Thermal water energy has been successfully used for hatching poultry and for the growth of mushrooms in an enclosed hut, 500 sq m in area, by the Regional Research

Inviting articles for Akshay Urja

The need to have a sustainable supply necessitates the exploitation of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. RE can play an important role in resolving the energy crisis in urban areas to a great extent. Today RE is an established sector with a variety of systems and devices available for meeting the energy demand of urban inhabitants, but there is a need to create mass awareness about their adoption. Akshay Urja is an attempt to fulfil this need through its dissemination of 20,000 copies in India and abroad. The magazine publishes news, articles, research papers, case studies, success stories, and write-ups on RE. Readers are invited to send material with original photographs and statistical data. The photographs should be provided in high resolution files on a CD or through email. Akshay Urja will pay a suitable honorarium to the authors for each published article of 1500 words and above. The publication material in two copies, along with a soft copy on CD/DVD/e-mail may be sent to

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> **It is necessary to launch drilling to depths of 1500m to 2500m followed by well testing and reservoir evaluation in the promising geothermal areas of the country.**

Laboratory, Jammu. Green house cultivation has been successfully tried at Chhummathang.

At Manikaran (Parbati Geothermal Field) thermal waters have been utilised for developing a 7.5 tonne capacity cold storage plant based on the ammonia absorption system. A five kWe binary power plant has also been test run successfully. The Beas Geothermal System's waters have been utilised at Bashisht and Kalath. The waters at Kalath can even be utilised for mineral water bottling. No experimental utilisation studies have been carried out at the Tattapani Geothermal System. Installation of a 300 kWe pilot binary cycle power plant as a collaborative project between GSI, Oil and Natural Gas Commission (ONGC) and Madhya Pradesh Urja Vikas Nigam, Bhopal, utilising the thermal fluid discharge from the bore holes drilled by GSI is under consideration. No attempt has been made to use the thermal waters in the west coast geothermal field and although 18 thermal spring locations occur along the west coast, only three areas (Unhavre-Khed, Tural, Ganeshpuri) have potential for use and that too for non electrical purposes. Studies carried out so far have clearly pointed to the presence of geothermal fluids with limited output and moderate temperatures up to a depth of 500m and to the strong possibilities of encountering vast resources of geothermal fluids at high temperatures and pressures at deeper levels in many areas in the country. The need, therefore is to explore deeper levels of geothermal reservoirs containing sizeable quantity of thermal fluids at high temperatures and pressures which could be depended upon for power production of MW level and direct heat applications on an industrial scale. It is therefore necessary to launch drilling to depths of 1500m to 2500m followed by well testing and reservoir evaluation in promising geothermal areas of the country. Indeed geothermal energy, if adequately exploited, can help tide over the energy crisis and prove to be a dependable source of alternate energy. ❂

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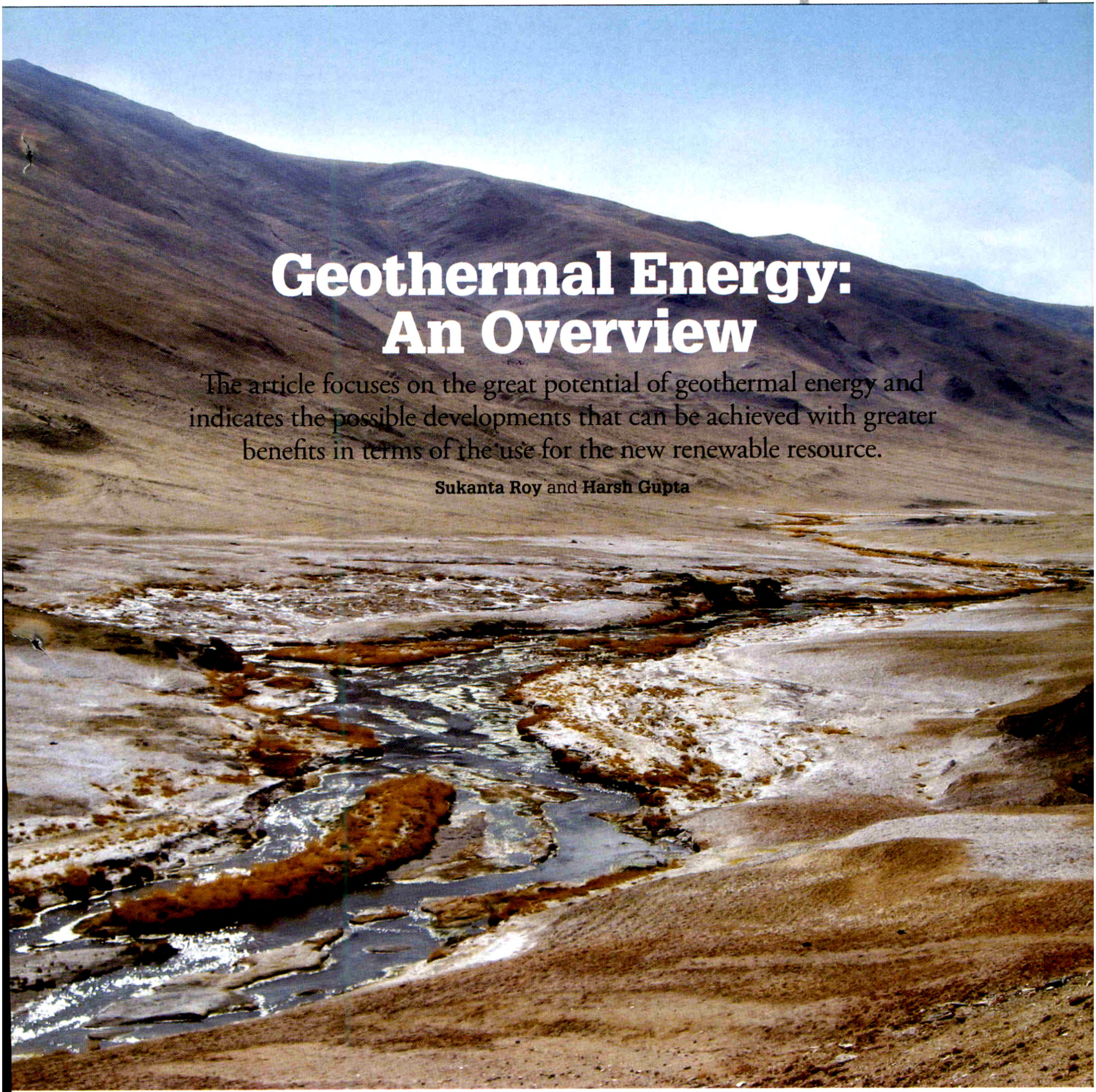
Geothermal Energy: An Overview

The article focuses on the great potential of geothermal energy and indicates the possible developments that can be achieved with greater benefits in terms of the use for the new renewable resource.

Sukanta Roy and **Harsh Gupta**



The benefits of using geothermal energy as an alternative resource are immense. Renewable, low running cost, capability to provide base load power, and small environmental footprint make this resource a preferred choice among other energy resources. However, considerable research and development is needed to take advantage of this buried wealth. The future use of geothermal energy would depend not only on overcoming technical barriers related to its utilisation and the economic viability compared to other energy resources but also on favourable policy initiatives from the government.

With rapidly increasing energy demands in growing economies such as India, it is important to include

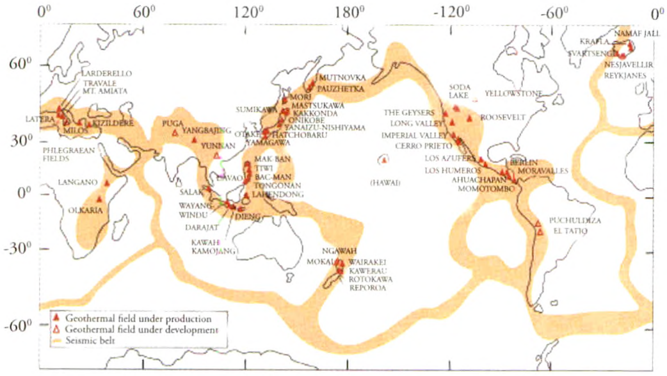


Fig 1. Map showing the distribution of geothermal fields under production (filled triangles) and under development (open triangles) [H. Gupta and S. Roy, Geothermal Energy: An Alternative Resource for the 21st Century, Elsevier, 2006]. Geothermal fields cluster near the tectonically active plate boundaries that are characterized by Quaternary volcanism.

Table 1. Countries Generating Geothermal Power in 2010

Countries	Installed Capacity (MW)	Rank
United States	3,086	1
Philippines	1,904	2
Indonesia	1,197	3
Mexico	958	4
Italy	843	5
New Zealand	628	6
Iceland	575	7
Japan	536	8
El Salvador	204	9
Kenya	167	10
Costa Rica	166	11
Nicaragua	88	12
Russia	82	13
Turkey	82	14
Papua New Guinea	56	15
Guatemala	52	16
Portugal	29	17
China	24	18
France	16	19
Ethiopia	7.3	20
Germany	6.6	21
Austria	1.4	22
Australia	1.1	23
Thailand	0.3	24

Source: www.geo-energy.org

sustainable energy resources in its fossil-fuel-dominated primary energy mix. Geothermal energy is one such resource derived from the Earth's internal heat, which has been catering successfully to both industrial as well as domestic energy requirements in many parts of the world over the past few decades. Being abundant, environmentally benign and renewable, it is a preferred choice for an alternative energy resource. Besides conversion to electric power, the direct uses of geothermal heat have the potential to replace substantial quantities of fossil fuels.

The worldwide utilisation of geothermal energy has increased rapidly during the last three decades mainly from variable capacity additions by Phillipines, United States, Italy, New Zealand, Iceland, Costa Rica, El Salvador, Guatemala and Russia (Table 1.). Today, besides being used in at least 24 countries to generate electricity totalling to about 10,700 MW installed capacity (R. Bertani, Proceedings, World Geothermal Congress, Indonesia, 2010), geothermal energy is being used in more than 58

Table 2. Major hot spring groups in India, their tectonic settings and temperatures of surface waters[1]

Major hot spring groups	Tectonic setting	Temperature range of surface discharge, °C
Indus valley (Puga, Chhumathang)	Higher Himalaya (active tectonic zone)	75-100
Parbati valley (Manikaran), Beas valley, Satluj valley, Tapoban group in Uttarakhand, etc	Central to Lesser Himalaya	50-90
Tattapani group, Chhattisgarh	Central Indian Shield (stable craton)	75-100
Son-Narmada-Tapti lineament zone (SONATA)	Central Indian Shield	30-65
Bakreshwar-Tantloi, Monghyr, Rajgir, Surajkund, etc	Eastern India (stable craton)	45-71
West Coast group, Maharashtra	Deccan Traps (stable craton)	35-70

1 In addition to the major hot spring groups listed above, several low-to-moderate temperature springs occur in Haryana, Gujarat, Andhra Pradesh, Karnataka, Odisha, Assam, Meghalaya and Arunachal Pradesh

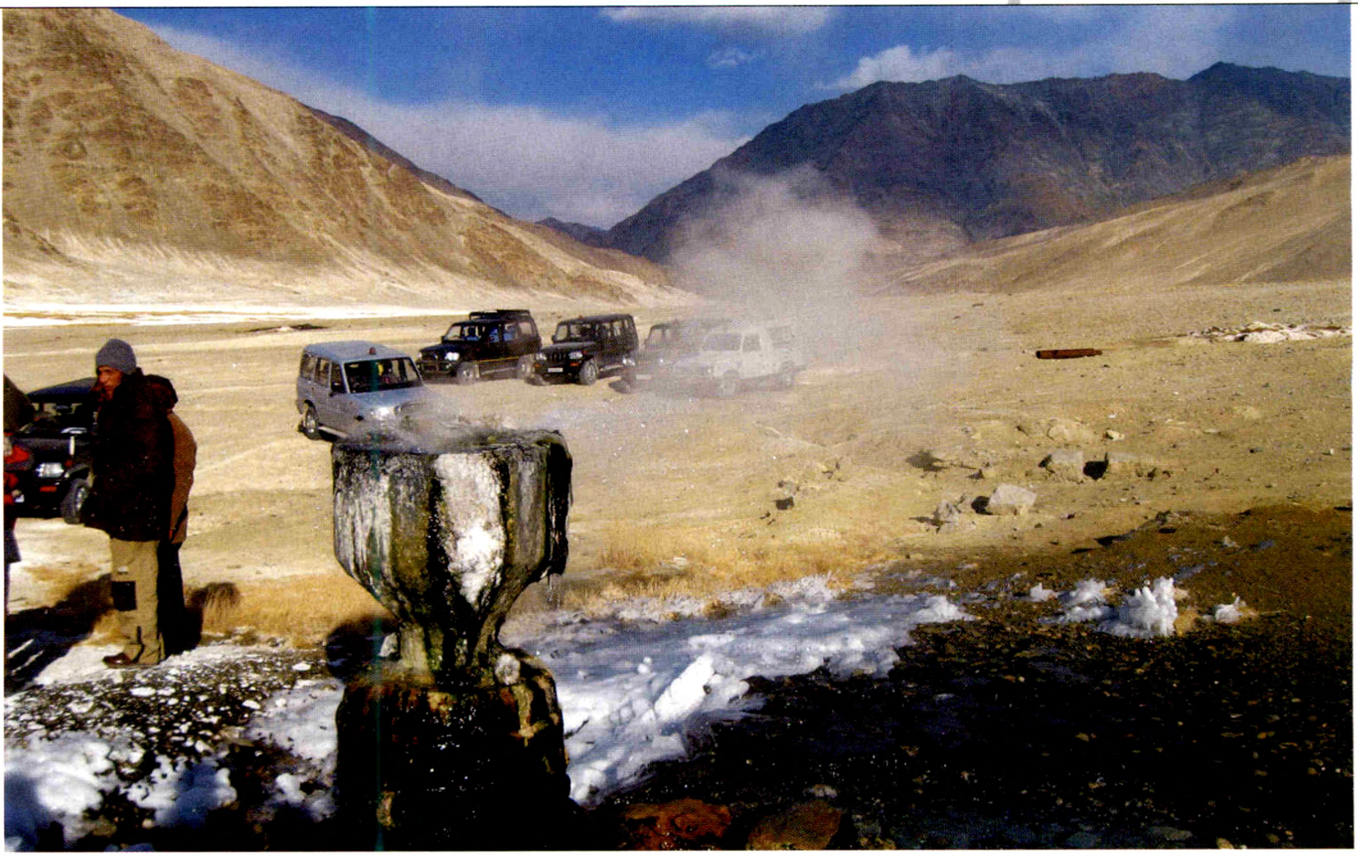


Fig 2. Steam leaking out of an old well drilled in Puga valley in mid-1980s

countries for direct uses (space heating and cooling, health spas, fish farming, agricultural and industrial purposes). In several developing nations, devoid of adequate conventional fossil fuels, there is a large potential for use of geothermal resources. For example in Tibet, with no readily available fossil fuels, the Nagqu geothermal field provides a useful energy source for the local population with the help of a 1 MW binary plant built in 1993.

Geothermal Exploration in India

In most precambrian terrains including India, moderate-to-low temperature hot water spring systems represent the potential geothermal energy resources. This scenario is in contrast to steam and/or steam and hot water based geothermal fields under production in other parts of the world, which are located predominantly in quaternary volcanic / magmatic settings (Fig 1). The major groups of hot springs in India occur in the Indus valley (Fig 2, Puga - Chhumathang), Parbati valley (Manikaran) and Tapoban areas in the Himalaya; along the west coast of Maharashtra in western India; the Son-Narmada-Tapti lineament zone in central India; Tattapani (Fig 3), Rajgir-Monghyr, Surajkund and Bakreshwar in eastern India. The distribution of major groups of hot springs in India is shown in Fig 4 and temperature ranges of geothermal waters are listed in Table 2. Most hot springs occur in the foothills or river valleys and the waters are predominantly meteoric in origin. No evidence of quaternary magmatism is reported, except in the case of Puga-Chhumathang areas where conclusive evidence is lacking. Therefore, the preferred model for most hot springs in India is that of rainwater/snowmelt infiltrating into the subsurface, the downgoing waters picking up heat from the Earth's normal heat flow and returning to the surface through fault / fracture systems. Geothermal springs have been used mainly for balneological purposes and religious tourism. However, India is yet to produce electric power from geothermal energy, except for a nominal, 5kW, binary plant at Manikaran that was operational for a very short time only.

Among the most notable achievements during the past five decades has been the assessment of geothermal fields by the Government of India in 1966 and publication of a comprehensive report in 1968 recommending preliminary

> **India is yet to produce electric power from geothermal energy, except for a nominal, 5kW, binary plant at Manikaran that was operational for a very short time.**

> **In recent years, the Ministry of New and Renewable Energy (MNRE), has shown renewed interest in geothermal exploration in different geothermal areas of the country.**

prospecting of the Puga and Manikaran geothermal fields in the Himalaya (Report of the Hot Springs Committee, Govt. of India, 1968). A major, systematic, multi-disciplinary, multi-institutional programme (including drilling up to 385 m) covering the Puga-Chumathang geothermal fields in Ladakh was mounted during 1972-74 under the stewardship of V.S. Krishnaswamy of the Geological Survey of India (GSI) and complemented by scientists from the Council for Scientific and Industrial Research-National Geophysical Research Institute (CSIR-NGRI), Central Electricity Authority and others. The shallow subsurface features were delineated in considerable detail that resulted in building a proposal to set up a pilot-scale, 1 MW binary-cycle power plant at Puga. The proposal is yet to be implemented. Attempts to revisit the geothermal exploration in the area include a number of geochemical studies (see for example, Geothermal Energy in India, U.L. Pitale and R.N. Padhi (Eds.), Geological Survey of India, Special Publication 45) and recent magnetotelluric studies (Abdul Azeez and Harinarayana, Curr. Sci., v. 93, p. 323-329, 2007). An expert group set up in 2008 by the Ministry of New and Renewable Energy, Government of India made strong recommendations to install pilot-scale plants by drilling exploration cum demonstration wells in the area (Report of Expert Group on Power Generation from Geothermal Energy at Puga, Jammu and Kashmir, India : Ministry of New and Renewable Energy, Govt. of India, 2008). This would be useful not only for monitoring the rates of hot water discharge and temperatures over a period of time but also studying the reservoir characteristics. Another major initiative, directed towards the hot springs of the West Coast belt and the Son-Narmada-Tapti belt that was taken up by the GSI with assistance from the United Nations Development Programme (UNDP) during 1976-77 and later extended for a few years, included deep drilling up to depth of 500 m (Records of the Geological Survey of India, v. 118, Pt. 6, 1987). The Tattapani hot springs in Chhattisgarh were identified for setting up of a 300 kW binary-cycle power plant. Although substantial geologic information on the Puga and Tattapani geothermal fields has been acquired, the lack of deep exploration, at least to depths of a few kilometres, hinders reservoir characterisation and evaluation of realistic geothermal energy potential. Much less information is available about the other geothermal fields in the country.

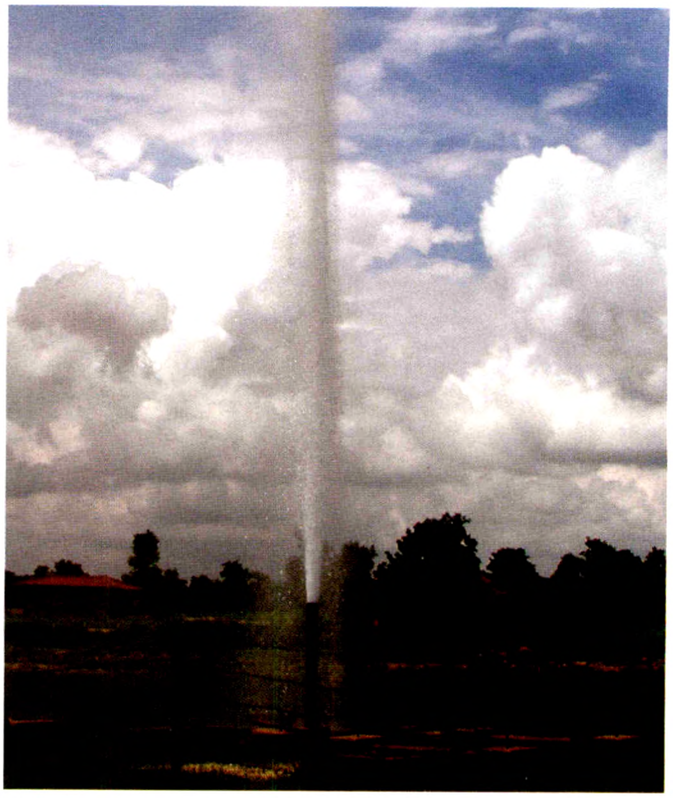


Fig 3. Hot water flowing out of one of the wells in Tattapani area, Surguja district in Chhattisgarh

In recent years, the Ministry of New and Renewable Energy (MNRE), Government of India has shown renewed interest in geothermal exploration in different geothermal areas of the country besides creating the framework for a national policy on exploitation of geothermal energy resources. Results emerging from these programmes will provide useful information and guide further exploration efforts in the country. Direct uses of warm-to-hot geothermal waters for greenhouse heating in cold climates, development of tourist spas, agricultural product processing, and extraction of rare materials like cesium also provide significant economic and environmental benefits from replacement of fossil-fuel use in environmentally sensitive areas.

Additionally, the CSIR-NGRI has a dedicated heat flow studies programme since its inception in 1962, which has

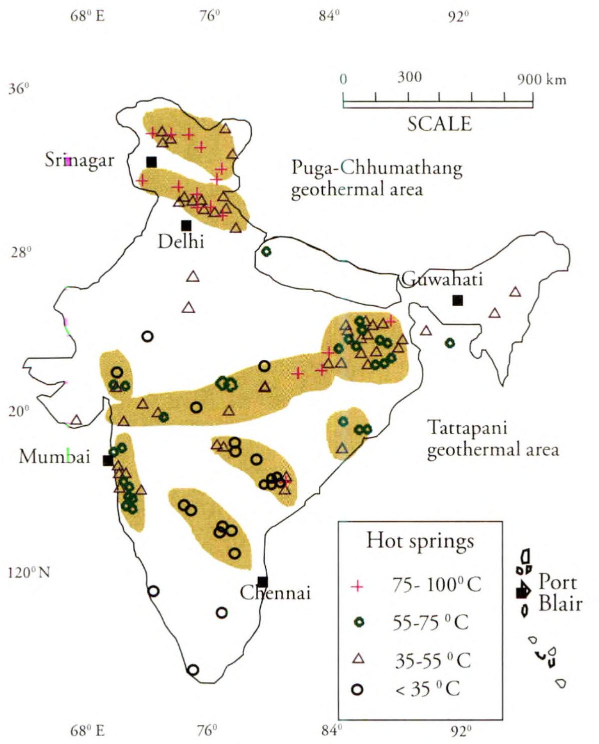


Fig 4. Outline of India showing the distribution of major groups of warm and hot springs [modified after Krishnaswamy, Proc. Second UN Symposium on Development and Use of Geothermal Resources, USA, 1975]. Temperatures of the hot spring waters are indicated using symbols (see legend). Shaded regions (exaggerated scale) show the major clusters of hot springs.

generated valuable data sets on the geothermal gradient and regional heat flow from temperature measurements in more than 500 boreholes covering a number of geologic and tectonic provinces in the country (S. Roy, Heat flow studies in India during the past five decades, Memoir 68, Geological Society of India, pp. 89-122, 2008). Detailed characterisation of thermophysical properties of major rock formations are carried out routinely to facilitate modelling of the temperature distribution in the crust in different parts of the country. Areas with anomalous high temperatures in the top 1-4 km of the crust, appropriate for enhanced geothermal systems (EGS) and hot sedimentary aquifers (HSA) could be delineated from such datasets.

Perspectives for Development of Geothermal Energy

Re-assessment of Energy Potential of Conventional Geothermal Resources: Temperature of hot spring waters at the surface is not the sole indicator of energy potential. The major question to be addressed is the sustainability of the resource, i.e., for how many years the production of hot waters at a certain minimum temperature and flow rate can be sustained. Answers to these questions require apriori information about characteristics of the subsurface reservoir and the nature of the heat source.

In view of the growing energy demands and the emphasis on renewable energy in India, a re-assessment of the geothermal energy potential of the Puga Valley hot springs in Ladakh and Tattapani hot springs in Chhattisgarh should be carried out. Critical gaps in information need to be covered through acquisition of new data, combined interpretation of geothermal datasets and existing geological, hydrological, geochemical and geophysical datasets to throw light on the nature of the heat source of the hot springs and their sustainability for power production, undertaking drilling and setting up of pilot-scale binary-cycle power plants. Scientific and statistical datasets including estimates of benefits from using geothermal energy should be compiled. These datasets could influence national policy decisions for providing tax incentives to investors and helping them tide over the increased upfront production costs of geothermal power when compared to conventional fuels.

Development of Appropriate Power Generation Technologies: Geothermal resources vary widely from one location to another, depending on the temperature and depth of the resource, the rock chemistry, and the abundance of groundwater. The type of geothermal resource determines the method of its utilisation. Variants of binary cycles appropriate to optimum utilisation of geothermal heat from moderate-to-low enthalpy springs in non volcanic settings such as those in India, need to be developed.

Efficient deep drilling technology is another important area requiring research and development in the country as drilling and distribution account for the largest costs, development of improved technologies to help contractors in difficult drilling environments help make deeper drilling economically viable, thereby providing access to higher temperature resources for power generation. Technological solutions to problems of corrosion and calcite deposition in pipelines, usually associated with geothermal systems, must be sought. Appropriate re-injection strategies, deep drilling and well stimulation are the key drivers for the producing fields to remain potential and economical in the long run.

Direct Heat Uses: The heat extracted from warm-to-hot waters emerging from other hot spring systems in the country can be gainfully employed for a number of direct uses such as development of tourist spas for bathing, swimming and balneology, greenhouse cultivation in cold climates, extraction of borax and rare materials such as cesium, and agricultural product processing. The significant economic and environmental benefits of using moderate-to-low enthalpy geothermal waters to replace even small on the utilisation of reducing equivalents with different nomenclature. Reducing equivalents facilitate hydrogen production in microbial electrolysis cell (MEC), by-product recovery either from anode or cathode chambers in bio-electrochemical system (BES) and enhanced pollutant removal using bio-electrochemical treatment system (BET).

Principle behind MFC Operation

The MFC functions on the basis of anodic oxidation and cathodic reduction reactions. The anode chamber is a biofactory which facilitates the generation of protons and electrons and plays a crucial role between physical and biological components. Protons reach the cathode through the proton excahnge membrane (PEM) resulting in a potential difference against which the electrons flow through the circuit (current) towards counter electrode (cathode) and get reduced in presence of oxygen forming water.

$C_6H_{12}O_6 + 6H_2O = 6CO_2 + 24H^+ + 24e^-$ (Anode)
$4e^- + 4H^+ + O_2 = 2H_2O$ (Cathode)
$C_6H_{12}O_6 + 6H_2O + 6O_2 = 6CO_2 + 12H_2O$ (Overall)

Electrons in the cascade of respiratory chain, transfers between the proteins through redox reactions based on the oxidation reduction potentials of the proteins. The proton flowing across inner and outer membranes based on the redox potentials of cascade, generates a proton motive force and it mobilises the electrons towards inter membranous space. Since electrons must transfer from a more negative potential to a less negative potential, the extra cellular electron transfer rate is influenced by the potential difference between the final electron carrier and the anode. Activity of anodic bacteria is essential to liberate electrons from the oxidation of organic matter and to transfer them to the electron acceptor. Electrons will be driven to the anode by a potential difference between the terminal intracellular electron acceptor and the anode either by direct electron transfer (DET) or mediated electron transfer (MET). Membrane-bound proteins or conductive biofilm (nano-wires) facilitate DET while MET occurs through soluble shuttling compounds. Microorganisms use more than one electron transfer mechanism to transfer electrons to the anode. The DET is considered to be a comparatively, more effective mechanism than the MET where the electron losses can be minimised prior to reaching the anode surface. Microorganisms are able to form a biofilm on anodes, which plays a crucial role in DET. The nature and group of consortia in the biofilm specifically regulates the electron discharge onto anode. Surface positive charge of anode gets increased due to the developed in situ bio-potential which enables the adhesion of negatively charged bacteria. Interaction among the microorganisms also facilitates efficient electron transfer.

Ecological engineered system embeded with fuel cell showing functioning of clock.

The MFC systems are designed with dual and single chamber configurations. The double chamber configuration has separate anode and cathode compartment connected through a PEM (Fig 1 and 2). The substrate gets oxidised in the anode chamber while reduction occurs in the cathode chamber. Catholytes such as potassium ferricyanide, potassium permanganate, aerated catholytes, etc. were used with variable degree of efficiency. The single chamber MFC configuration consists of the anode chamber only, while cathode is placed in such a way that it is exposed to air (open-air cathode) (Fig 3). Few other configurations viz., flat plate, tubular, cubical, stack, etc. have also been used for MFC operation. The solid phase microbial fuel cell (SMFC) was designed by Council for Scientific and Industrial Research-Indian Institute of Chemical Technology (CSIR-IICT) to evaluate the potential canteen based food waste as substrate for bioelectricity generation. A photo-bioelectrocatalytic/ photo-biological fuel cell (PhFC) was designed by CSIR-IICT to evaluate bioelectricity generation using photosynthetic consortia as the biocatalyst in the mixotrophic mode. Syntrophic association of photosynthetic bacteria and algae showed feasibility of power generation under anoxygenic microenvironment by the PhFC. Benthic/sediment type fuel cell application for bioelectricity generation was evaluated in different types of water bodies. Nature, flow conditions and characteristics of water bodies influence the power generation apart from electrode assemblies, surface area of anode and anodic material. The CSIR-IICT evaluated designed miniatured floating macrophyte based ecosystem with Eichornia as the major biota for bioelectricity generation from wastewater treatment employing three fuel cell assemblies (similar to benthic fuel cell). Based on the observations made from various lab scale optimisation studies, the CSIR-IICT developed a semi-pilot scale hybrid bio-electrochemical system with 100 litre capacity using multiple electrode assemblies connected in series (36 chambers) (Fig 4). The semi-pilot scale MFC without membrane was evaluated for one year using domestic sewage operated under anoxic conditions.

MFC is a hybrid bioelectrochemical system which transforms chemical energy stored in the biodegradable substrate to electrical energy via microbial catalysed redox reactions.

Wastewater vs Bioelectricity

The concept of the MFC is well established in the direction of utilising wastewater as an anodic fuel making it a sustainable technology for energy generation as well as waste management. Reducing the cost of wastewater treatment and finding ways to produce useful byproducts has been gaining importance in view of environmental sustainability. The organic matter present in wastewater serves as primary substrate for the fermentation process facilitating treatment of wastewater with simultaneous generation of bioelectricity. Theoretically, one kg of chemical oxygen demand (COD)removed can produce 170 W of power. According to an estimate, about 300 million tons of wastewater is generated annually in India by dairy industries which can generate bioelectricity using the MFC method (calculated assuming 40 per cent energy conversion efficiency; 14.7 KJ/g-COD) accounting for a revenue of Rs 12 billion per annum (at a rate of Rs 4 per kW/h) along with its treatment. Domestic sewage generated in urban and rural areas of India was estimated to be around 1,42,405 million litre/day (MLD) which could generate about 300 MW/h power accounting for a cost of about Rs 108 billion per annum apart from treatment. This gives a clear estimate about the inherent power present in wastewater that can be harnessed for bioenergy. Wastewater from food waste, electroplating, starch processing, breweries, paper industry, palm oil mill, chocolate industry, domestic sewage, cellulosic waste, vegetable waste, composite chemical wastewater, pharmaceutical wastewater, swine waste, etc. were evaluated at a laboratory scale to understand their potential as anodic fuel and the possibility of power generation from various types of wastewater was evaluated at CSIR-IICT (Table 1).

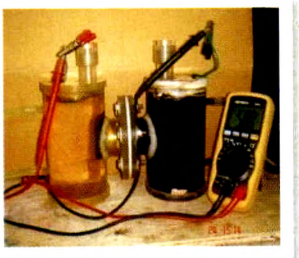


Fig 1. Clock function with power from emdeded benithic fuel cell (L). Fig 2. Photograph showing dual chamber MFC with ferricyanide cathode (R).

MFC as Treatment Unit

The MFC can also be termed as a bio-electrochemical treatment (BET) system. The principle of BET relies on the fact that electrochemically active microorganisms can transfer

Table 1. Bioelectricity production from various wastewaters as substrate evaluated in different types of MFC configurations

Waste/ Wastewater	Maximum Voltage (mV)	COD removal (per cent)	Volumetric Power (W/m³)
Composite Chemical	731 (dual)	61.1 (dual)	4.95 (dual)
Pharmaceutical	339 (single) 625 (hybrid)	76.0 (single) 92.1 (hybrid)	8.40 (single) 0.99 (hybrid)
Dairy	308 (single)	95.5 (single)	3.56 (single)
Distillery	351 (single)	72.8 (single)	4.96 (single)
Canteen Waste	332 (single)	88.7 (single)	2.17 (single)
Domestic Sewage	449 (single)	66.7 (single)	2.25 (single)
Designed Synthetic	586 (dual) 308 (single)	72.2 (dual) 43.7 (single)	3.95 (dual) 1.86 (single)
Vegetable Market Waste	308 (single)	80.0 (single)	4.60 (single)
Citrus Peelings	321 (single)	71.0 (single)	1.76 (single)

*Power yield varied between 5-12 W/kg CODR electrons from a reduced electron donor to an electrode and finally to an oxidised electron acceptor generating power. During a BET operation, there exists a possibility to integrate diverse components viz., biological, physical and chemical in the anodic chamber and provides an opportunity to trigger multiple reactions viz., bio-chemical, physical, physico-chemical, electrochemical, oxidation, etc., as a result of substrate metabolic activity and subsequent secondary reactions. The anode chamber of the BET resembles the conventional anaerobic bioreactor and mimics the function of a conventional electrochemical cell used for wastewater treatment where the redox reactions help for the degradation of organic matter and toxic/xenobiotic pollutants. Anodic oxidation and cathodic reduction reactions will have a positive influence on the pollutant removal in the BET system. The in situ bio-potential generated during the process helps in the enhanced degradation of different pollutants in both the anode and cathode chambers. Direct anodic oxidation (DAO) and indirect anodic oxidation (IAO) facilitate the effective removal of pollutants. The DAO facilitates the degradation of pollutants absorbed on the anode surface by anodic electron transfer reactions. The oxidants formed electrochemically on the anode surface in turn oxidise the organic matter by IAO. The DAO of the substrate facilitates the formation of primary oxidants which could further react on the anode, yielding secondary oxidants such as chlorine dioxide and ozone, which might have a positive effect on the colour removal efficiency through the oxidation process. This process helps to oxidise the organic matter by the liberated oxidation species which might enhance the substrate removal. Reactions between water and radicals near the anode could yield molecular oxygen, free chlorine, hydrogen peroxide, hypochloric acid, etc. which also helps in colour/organic oxidation. Pollutants in the anodic chamber also act as mediators for the electron transfer to anode which can increase the power generation efficiency with simultaneous reduction of pollutants. Various pollutants such as dyes, organic pollutants, solvents, inorganic salts, complex wastewater, coloured substances, synthetic estrogens, PAHs, etc. are reported to be treated in these systems. Application of biocathode also helps in enhancing wastewater treatment efficiency especially in the removal of specific pollutants. Biocathodes reportedly reduced pollutants such as nitrates or sulfates or chloroorganics in the cathode compartment.

Bio-electrochemical treatment is gaining prominence in the recent past which facilitates enhanced treatment efficiency with simultaneous energy generation.

Factors Influencing Bioelectricity Generation

Electrical energy can be obtained from fuel cell operation only when a reasonable current is drawn, but the actual cell potential is decreased from its equilibrium potential because of irreversible losses present in the fuel cell. Electron transfer from the biocatalyst to the anode and then to the cathode is generally hampered by different losses which lower the conversion efficiency. There exists a close similarity between bio-electrochemical and biochemical reactions wherein both encounter an activation barrier that must be overcome by the reacting species or biocatalyst. The power generation capacity of the MFC depends on the catabolic activity of the anodic biocatalyst and its electron transfer efficacy to the anode. However, the transfer of electrons between the biocatalyst and the anode is low because of the sluggish kinetics which subsequently results in a low power yield. The electron transfer resistances in the MFC arise due to factors such as the reactor configuration, materials used, nature of anolyte and metabolic activities of the biocatalyst, which tend to decrease the MFC performance pertaining to power generation as well as substrate degradation. The power output of the MFC can be improved by enhancing the electron transfer efficiency between the biocatalyst and the anode. Most of the earlier studies with the MFC were reported with pure culture as biocatalyst with simple defined substrates. However, usage of mixed culture instead of single strains is always a better option in the MFC operation because of ease in maintenance and their survivability even in wastewater. Selective enrichment of the mixed culture with an electrochemically active bacterial population will have more benefits. Poising mild potentials during reactor start up, growth under restricted electron mediating conditions, bio-augmentation of electrochemically active strains, etc., are few strategies developed for the selective enrichment of biocatalysts. The nature of the anode will also have significant influence on the substrate conversion efficiency and the synergistic interaction between anode and biocatalyst is crucial for efficient extracellular electron transfer. High electrical conductivity (low electrical resistance), inert nature (non-oxidation/non self-destructive nature), sustainability of properties with time, etc. are some of the important properties of the anode which can influence the performance of the MFC. More often, graphite is used as a bioanode material for fuel cell applications in both catalysed and non-catalysed forms. Few other materials viz., platinum, stainless steel, nickel, etc., were also used as anode apart from carbon based materials. Extracellular electron transfer will be high under acidophilic pH compared to neutral and basic pH due to the higher activity of intracellular electron carriers which helps in translocation of electrons from bacteria to the extracellular environment. On the contrary, wastewater treatment was reported to be higher under neutral pH. Ion exchange membrane between anode and cathode for the development of a gradient is also an important factor that influences the MFC performance. Usually, the anode chamber of MFC will be operational in an anaerobic microenvironment. However, very few studies have reported that, aerobic microenvironment under low DO - dissolved oxygen (anoxic) conditions and high substrate concentration will have a potential to generate power. Cathodic reduction of reducing equivalents is crucial along with the anodic oxidation for power output in the MFC system. Reduction reaction at the cathode indirectly influences the substrate oxidation in the anode as well as it can help to overcome the electron losses. Microorganisms can also be used as a catalyst in the cathode chamber for improved cathodic reduction reaction where biocatalysts retrieve electrons directly from the cathode which are then transferred to a final electron acceptor such as oxygen, nitrogen, sulfur, etc. The electron transfer in the MFC can also be increased by using different types of artificial and natural mediators. Genetic modification of specific genes in the biocatalyst related to the proteins that function for the exocellular electron transfer, was also reported by a few researchers. The operation of the MFC under the optimised conditions with selectively enriched mixed culture as catalyst and wastewater as substrate will have a commercial viability in the near future.

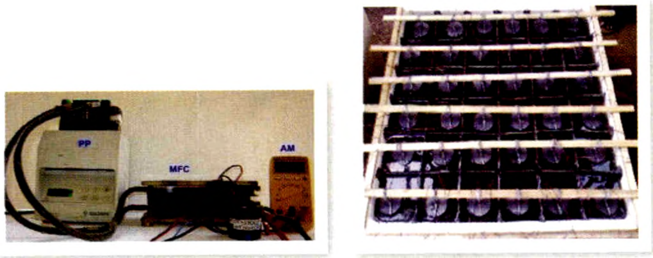


Fig 3. Photograph showing single chamber MFC with open-air cathode (L). Fig 4. Semi-pilot scale MFC (without membrane) with 100 litre capacity was designed with 36 chambers and evaluated for more than one year using domestic sewage (R).

BET relies on electrochemically active microorganisms that can transfer electrons from a reduced electron donor to an oxidised electron acceptor generating power.

Future Scope

The MFC is poised to change the visage of the energy scenario and wastewater treatment processes in the near future. However this requires extensive research with respect to appropriate design of fuel cell, effective reactor configuration, low cost components of fuel cell, reduction in electron loss, etc. Interaction between the anode and the biocatalyst needs to be understood and optimised to fully exploit the capacities of these systems. At present, apart from power generation, the MFC application has been extended towards waste remediation, specific pollutants removal and recovery of value added products. Bio-electrochemical treatment is gaining prominence which will facilitate enhanced treatment efficiency with simultaneous energy generation. Based on the oxidation reduction reactions occurring in the MFC, various complex pollutants can be removed by increasing the power generation potential, especially in the cathode chamber. The other face of the MFC is recovering value added products from the carbon source present in waste through bio-electrochemical process and the conversion of wastewater components or CO_2 into valuable products under mild applied potential. This is based on the reduction mechanism at cathode and by reducing the activation energy required for the conversion of waste carbon to valuable product through applied potential associated with the in situ biopotential. Biocatalysed electrolysis is a novel H_2 production process with a potential of converting dissolved organic substances in wastewater, in the absence of electron acceptor under small external voltage (>0.2 V in practice). Other value added products viz., ethanol, butanol, etc., can also be recovered at cathode of bioelectrochemical systems but these studies are at an early stage and needs optimisation of process parameters. The applications of the MFC are at present in the developing stage, but it will make every effort to meet the energy needs of society by utilising waste carbon resources in the near future. ✪

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Hydrogen - A Promising Renewable Fuel

Hydrogen as an everyday fuel is indeed a revolution in science. Useful as a compact energy source in fuel cells and batteries, it is renewable and causes no pollution. Though the discovery of its use is considered a breakthrough, its cost effectiveness is yet to be ascertained.

Prof. Dileep Kumar Krishna Nayak and **Prof. Usha Raghavan**

Revolutions in science and industrialisation may have enhanced the use of machines. Indeed these machines help improve the quality of human life. However, it is well known that these require energy and consequently, the energy requirement of the world is increasing at an alarming rate. According to the recent World Energy Outlook 2008, we derive around 80 per cent of our energy from fossil fuels like crude oil (36 per cent) natural gas (21 per cent) and coal (23 per cent) (Fig 1). It is also well known that these fossil fuels are exhaustible and will get depleted very soon. Hydrocarbon resources are in the mid depletion stage and are likely to last for about five decades whereas coal reserves may be adequate for only a couple of centuries.

Most developing nations have a huge difference between the demand and supply of electrical energy. To keep pace with advancement and progress it has become necessary to strengthen power generation capabilities thus taking a toll on the available fossil resources. The growing population has increased the pollution levels in the atmosphere and the resultant emissions in our environment have shown serious consequences. All over the globe, regulatory bodies have suggested reduction in emissions. In such a scenario wherein efforts are being made to minimise the damage caused, through improved technologies with cost implications, renewable energy sources seem to be the ultimate solution for the energy deficit.

Clearly, hydrogen is poised to be one of the potential energy sources of the future. It has three basic benefits:

- The use of hydrogen largely reduces pollution. When hydrogen is combined with oxygen in a fuel cell, energy in the form of electricity is produced.
- Hydrogen can be produced from numerous sources such as methane, gasoline, biomass, coal or water.
- If energy is produced from water, it becomes a sustainable production system.

Thus, the issues related to energy, pollution, environment and sustainability can be tackled effectively using hydrogen energy. Hydrogen is also the lightest of all elements and is available in abundance. If a matured technology is developed, hydrogen can become the cleanest, most efficient and cost effective fuel. The main advantage of hydrogen energy is that it is produced from water, used as an energy carrier and its byproduct is also water. Extensive research is taking place for the generation of pure hydrogen, its handling, storage, efficiency and safety aspects.

Properties of Hydrogen

Hydrogen is a light, odourless and colourless gas with a density that is 14 times lesser than that of air at standard temperature and pressure and liquefies at temperatures below -253° C. Its energy per unit mass content is around 141.9 MJ/kg which is around thrice of that of gasoline. Hydrogen does not occur naturally as a gas on earth - it is always found in combination with other elements. It is present in large quantities in water as also in many organic compounds - in gasoline, natural gas, methane, etc.

Production of Hydrogen

Hydrogen is produced using various technologies; depending on the methods by which hydrogen is liberated, they are classified as steam reforming, electrolysis of water, gasification and partial oxidation.

Steam Reforming: The method consists of reforming hydrocarbons into their compounds with steam, using endothermic reaction. Hydrocarbons, mixed with steam at a temperature of about 1100° C under pressure, using a catalyst such as nickel, react to release hydrogen.

> **The use of hydrogen largely reduces pollution. When hydrogen is combined with oxygen in a fuel cell, energy in the form of electricity is produced.**

Electrolysis of water: Water breaks apart into hydrogen and oxygen when an electric current is passed through the electrolyte. The positively charged ions are attracted by the cathode where H_2 molecules are released. Oxygen is released at the anode. This method needs electric current which can be provided through renewable sources like solar, wind, etc.

Gasification: It is one of the oldest methods in which biomass or coal when mixed with a limited amount of oxygen at around 900°C, produces a synthesis gas (syngas) which contains hydrogen. After cleaning, it can be reformed into hydrogen.

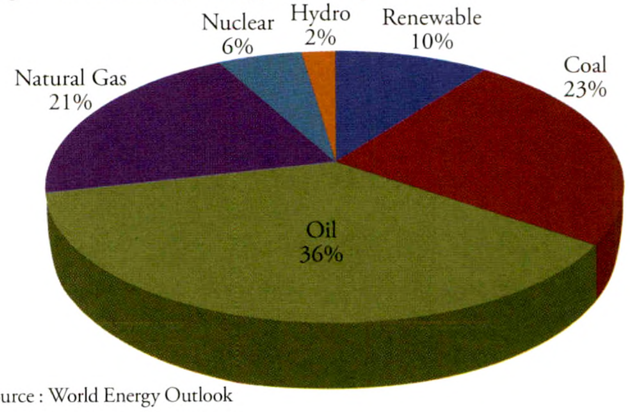
Partial Oxidation: The thermal degeneration of hydrocarbons produces hydrogen. Raw materials such as natural gas, oil, gasoline are used for the conversion.

Storage of Hydrogen

Hydrogen storage is one of the critical issues for successful implementation, commercialisation and sustainability of mobile applications like hydrogen fuelled automobiles. Various technologies used for storage of hydrogen are:

- Compressed hydrogen is essentially the gaseous state of hydrogen gas which is kept under pressure. Pressure in the order of 5000 psi - 10000 psi is used for hydrogen vehicles. However, the size of the tank is large which makes the storage system heavy.

Fig 1. World Primary Energy Consumption, 2008



Source : World Energy Outlook

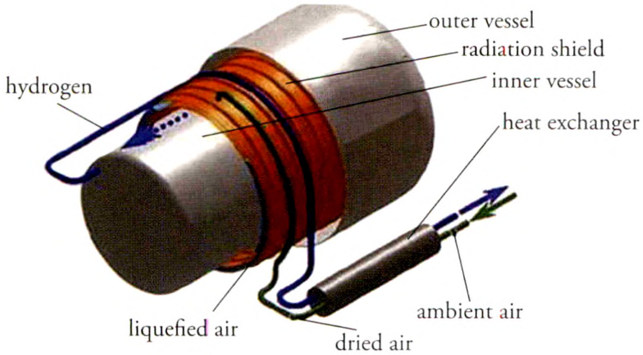


Fig 2. Storage of liquid Hydrogen

- Liquid hydrogen (Fig 2) or slush hydrogen requires cryogenic storage (20 K). Liquefaction imposes a large energy loss since energy is required to cool it down to that temperature. The tank must be well insulated and is the kind that can be used in space shuttles.
- Hydrogen can be stored in solid porous materials. Gas-on-solid absorption is inherently safe providing high density storage and increased safety.
- Carbon nanotubes can be a promising mechanism for hydrogen storage. One of the critical factors in the usefulness of carbon nanotubes, as a storage medium is the ratio of stored hydrogen to carbon. According to the US Department of Energy, a carbon material needs to store 6.5 per cent of its own weight in hydrogen to be considered as a fuel for automobiles.

Storage of Liquid Hydrogen

Safety: Certain safety issues that concern the use of hydrogen as a fuel are that it is odourless, colourless and tasteless making it undetectable by human senses. Hence, a leakage will be very difficult to detect. Hydrogen burns very quickly and has a tendency to combine with other elements. Hence, before hydrogen is made available as a popular transport fuel, it is essential to make sure that the fuel is safe for mass storage. Issues related to control of combustion, explosion and detonation of hydrogen air mixtures are yet to be addressed.

Application: Hydrogen is high in energy, yet an engine that burns pure hydrogen produces no pollution. Hydrogen fuel cells have been used to power the electrical system of space shuttles. It is a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric vehicles. Hydrogen has the potential to be an important energy carrier that can be delivered in a usable form to consumers.

> **Hydrogen has the potential to be an important energy carrier that can be stored, moved and delivered in a usable form to consumers.**

Conclusion

Renewable hydrogen as a transport fuel is an attractive option, which can help the world in environment protection. However, it is important to make this source safe and commercially viable. The innovations happening at research laboratories are likely to provide necessary results to make the hydrogen economy a reality.

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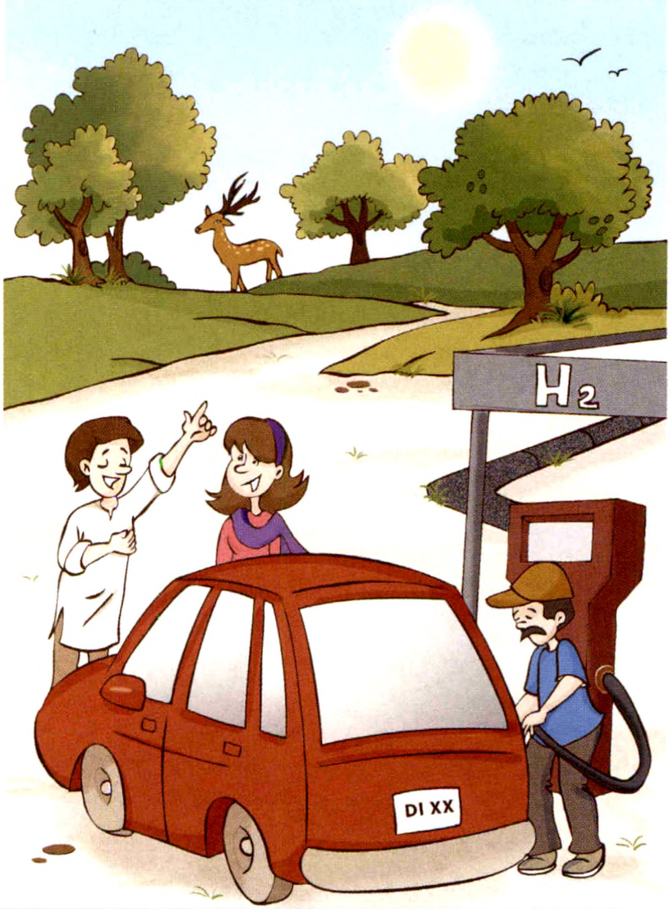
Cartoon



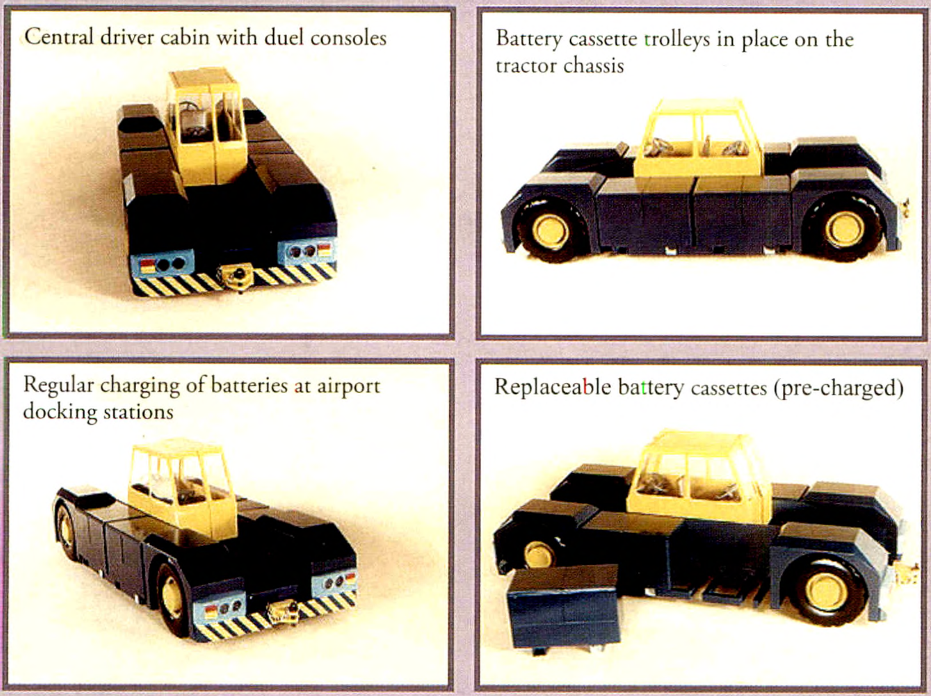
Electric Cars - The 'Green Answer' to the Energy Crisis

Growing environmental consciousness and the adverse effects of climate change, are propelling governments to support initiatives towards the development of eco-friendly mobility solutions including electric vehicles. Efforts have to be made to orient the use of electric vehicles to niche situations and markets where their limitations can be leveraged by design.

K. Munshi

Increasing environmental consciousness and in view of the harmful effects of climate change, the Government of India and those of various Indian states are supporting various initiatives for the development of technologies, and reduction of the carbon footprint emanating from India. Regulation has become one of the prime factors driving this change. Energy audits have been made mandatory in large consumer units, since March 2007. An energy labelling programme for appliances was launched in 2006 and comparative star-based labelling has also been introduced. With the recent signing of the agreement on Climate Change, in Copenhagen, India is committed to pursuing this policy aggressively. The Government of India's programme on 'Urban Renewal' insists on energy efficiency, and incentives in the form of cheaper loans are being offered to urban transport authorities. The National Solar Mission is promoting the use of solar energy for power generation and other applications. Energy efficiency has become the top most agenda for Indian companies as well. Big automobile companies are developing electric vehicle technologies and/or buying smaller electric vehicle companies to prepare for the future. A good example is that of Mahindra and Mahindra (M&M) who purchased the Reva Electric Car

Fig. 1 Aircraft Towing Tractor



Central driver cabin with duel consoles

Battery cassette trolleys in place on the tractor chassis

Regular charging of batteries at airport docking stations

Replaceable battery cassettes (pre-charged)

Company. Tata Motors has also initiated development of electric cars in various segments. They believe that the future belongs to smaller cars and have showcased their efforts at various motor shows around the world.

The Challenge

Although the first electricity driven car was driven in the 1880s, it lost the race to gasoline powered vehicles due to its deficiencies in range, weight and time of charging. Despite having made great strides in technology in the last 100 years, the electric vehicle still suffers from the same problems to date. What is however encouraging is that serious thought is being given to add value and make these vehicles viable 'somehow' and 'somewhere'. The rising cost of crude oil is helping this movement and the advantage is that it is posing challenges to various technology disciplines, and those working in these areas are doing their best to find solutions and attract research investment. With such inputs, it is bound to yield positive results in due course.

Strategy

Presently, on a global scale, effort is to build cars which can replace the existing petrol / diesel driven cars. However, this makes these cars very expensive and therefore unacceptable. It will take quite some time before these vehicles (hybrid or pure electric or hydrogen based) can compete on price with existing vehicles. As an immediate strategy to make electrical vehicles acceptable and usable, efforts may be made to design and orient the use of specialised electric vehicles to niche situations and markets, where these vehicles can have an intrinsic edge over conventional vehicles. This needs to be understood well. If the limitations of the electric driven vehicles are leveraged by design, then special vehicles for special applications / special situations can become viable and commonplace, thereby relieving the pressure on oil, environment (pollution), health and carbon footprint, to an extent.

The limitation of range if understood, can let us identify areas where the range of a vehicle is not important. One such example is the airport. Airports have become an essential infrastructure of a city, however small. Airports are highly, traffic and surface vehicle intensive and therefore one of the most polluted areas of a cityscape. If analysed, the airport can lend itself very easily to vehicle electrification. All buses running in the airport for ferrying passengers to and from the aircraft to the terminals could be electric vehicles. One can argue that aero-bridges obviate the need for such traffic. However, aero bridges in the context of developing countries like India are available only in a few large city airports. The rest are still dependent on gas guzzling, carbon dioxide fuming buses for ferrying millions of passengers across airports, all over the country. Although it seems so obvious that we should have 'electric ferry buses' on the airports, but one is yet to see even one electric bus on any Indian airport. In fact to make a small but very important beginning, not only buses, but all vehicles at the airports could be electricity driven, including aircraft tow tractor, baggage and food trolley towing tractors, maintenance runabouts, crew vehicles etc.

Case Study

A case study was developed through a project for the 'design of electric aircraft tow tractor' that tows the aircraft from runways to the tarmac or apron, and back. Presently it is a highly fuel guzzling and polluting vehicle, as it has to have weight (added through ballast) for traction to tow the heavy aircraft. Making it electric, can offer manifold advantages, which will be elucidated in the following case study. The disadvantage of an electric vehicle is that it is heavy, which is a positive aspect for an aircraft tow tractor. Cheaper, heavier and dependable lead acid batteries can be used as their high weight can create an advantage. The airport is a confined space; hence the range of the vehicle need not be large.

Intermittent usage (as it is not used all the time) of such vehicle can allow it to move to charging stations more often to get adequately charged. The structure of this vehicle need not be efficient and expensive (as in monocoque vehicles), but inefficient, heavy, rugged and less expensive. What we see here (Fig. 1) is that all the inherent disadvantages of an electric vehicle could be converted into advantages in this situation.

Similar advantages can be created in varying degrees in industrial campuses, gated communities, small urban clusters and similarly identified situations, with vehicles for different usages and where short ranges are fine.

> **Although the first electricity driven car was driven in 1880s, it lost the race to gasoline-powered vehicles due to the deficiencies of range, weight and time of charging.**

Education and Research

A new masters and doctoral level programme was started from 2010 for education and research into 'mobility and vehicle design' at the Industrial Design Centre, Indian Institute of Technology (IIT), Mumbai; and to eventually create a body of specialist vehicle designers, who can address the problems of future mobility and develop research culture in this discipline.

Research is being conducted on making light weight vehicles so as to reduce power consumption further. Integrated single unit reinforced plastic bodies for 2 wheelers and 3 wheelers have been built and tested to achieve this objective. An electric scooter (Fig. 2), which

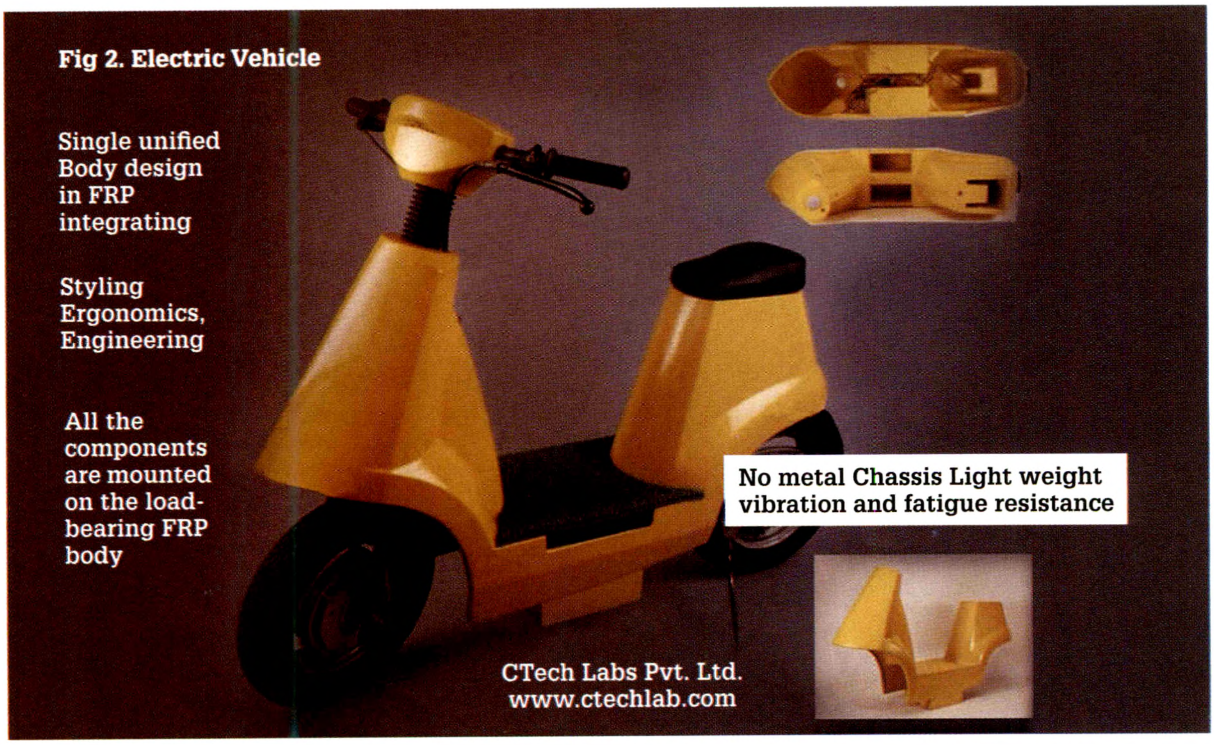


Fig 2. Electric Vehicle

Single unified Body design in FRP integrating
Styling Ergonomics, Engineering
All the components are mounted on the load-bearing FRP body
No metal Chassis Light weight vibration and fatigue resistance

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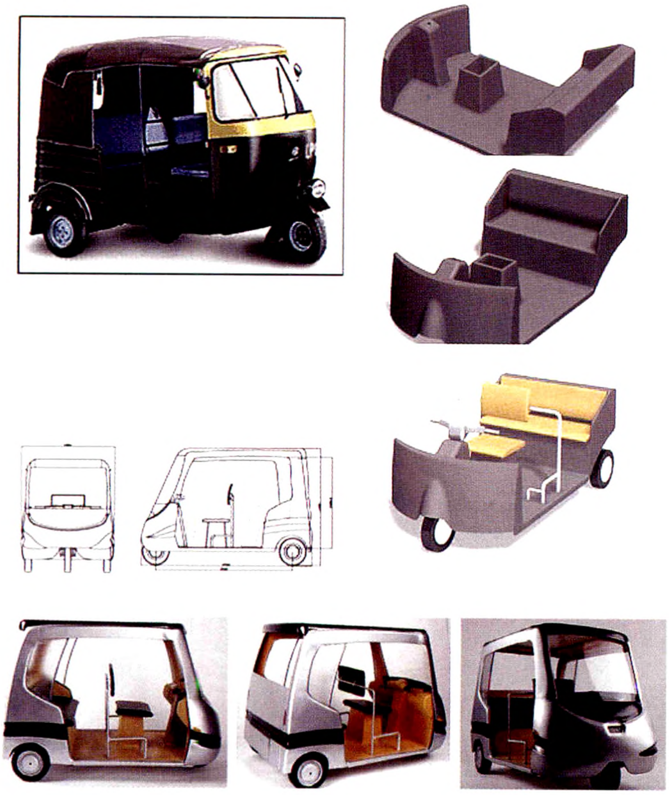

Fig 3. Designing an Electric Rickshaw
Prajwal Janardhana Ullal

weighs less than 40 kg and has a range of about 30 km is one such example. Prototypes of small electric vehicles, like 'electric auto rickshaws' and 'mini 3 wheelers' (Fig. 3) have been developed to prove the concepts. These concepts can be adopted and developed by 'research-shy' companies for manufacture and marketing.

Design Integration

Integrating computer and communication technologies with electric vehicles can become a big driver for development. One such example is the development of autonomous road trains for small tourist destinations / archeological locales, which are sensitive to pollution from high traffic. A project is being envisaged at IIT, Mumbai to develop a mobile facility at Elephanta Island, a small tourist spot near Mumbai, for tourists who visit the ancient caves there. An autonomous mini road train running on a battery bank charged through solar panels and following a 'tour line' is being contemplated. Besides being a facility for tourists, it offers an additional means of livelihood to the local community that is dependent on tourism. It can be showcased as a prototype for mobility solution in small towns particularly tourist towns.

Water in Pot Model

Traditionally the form or physiognomy of a product is dictated by the size of the components, mechanical linkages and their physical fitness. Emerging technologies are fluid in character, and therefore physically pliable. Like water, the usefulness of technology is dependent on the form of the container or 'pot' in which it is placed. For example, if water is to be drunk, it has to be kept in a glass or tumbler, and if it has to be poured, it is kept in a jug with a spout; and if it has to be carried, the pot takes the shape of 'narrow mouthed' vessel, so that it does not spill and so on. Besides the 'pot' has cultural connotations. For example, a teacup is not suitable for drinking water, though it can be used. Modern technology too, like fluid, when placed in a suitable 'container' performs better, if the shape of the 'container' is designed to suit the situations. Human and contextual issues are the determining factors for design. Major design criteria therefore have to be psycho-physiological, cultural and environmental.

Unique Form

Electric vehicles do not need the space as needed for voluminous internal combustion engines or bulky gear trains. The prime movers in electric cars are built into the wheels. The battery pack, particularly the newer polymer batteries are flexible and can be configured according to the availability of spaces and spread, and yet the electric vehicle simply looks like a sedan, or an SUV and even comes with 'air vents' in the front. The physiognomy of electric vehicles can be and should be quite different from what we see today in cars or hybrid vehicles. Industrial designers and stylists are working hard to invent a new formal language, which depicts the uniqueness of this breed of products. We have had similar difficulties in the past, when cars were made like horse buggies, and the first TVs were made to look like radios. Indeed with so much interest and so many people inspired to work in this area, the discovery of a new identity or an aesthetic breakthrough for electric vehicles is not a distant dream considering that new conceptual breakthroughs are being driven by the development of new technologies which have fairly matured and moved to the 'post failure' stage. The attempts in this direction are worth watching out for. ❂

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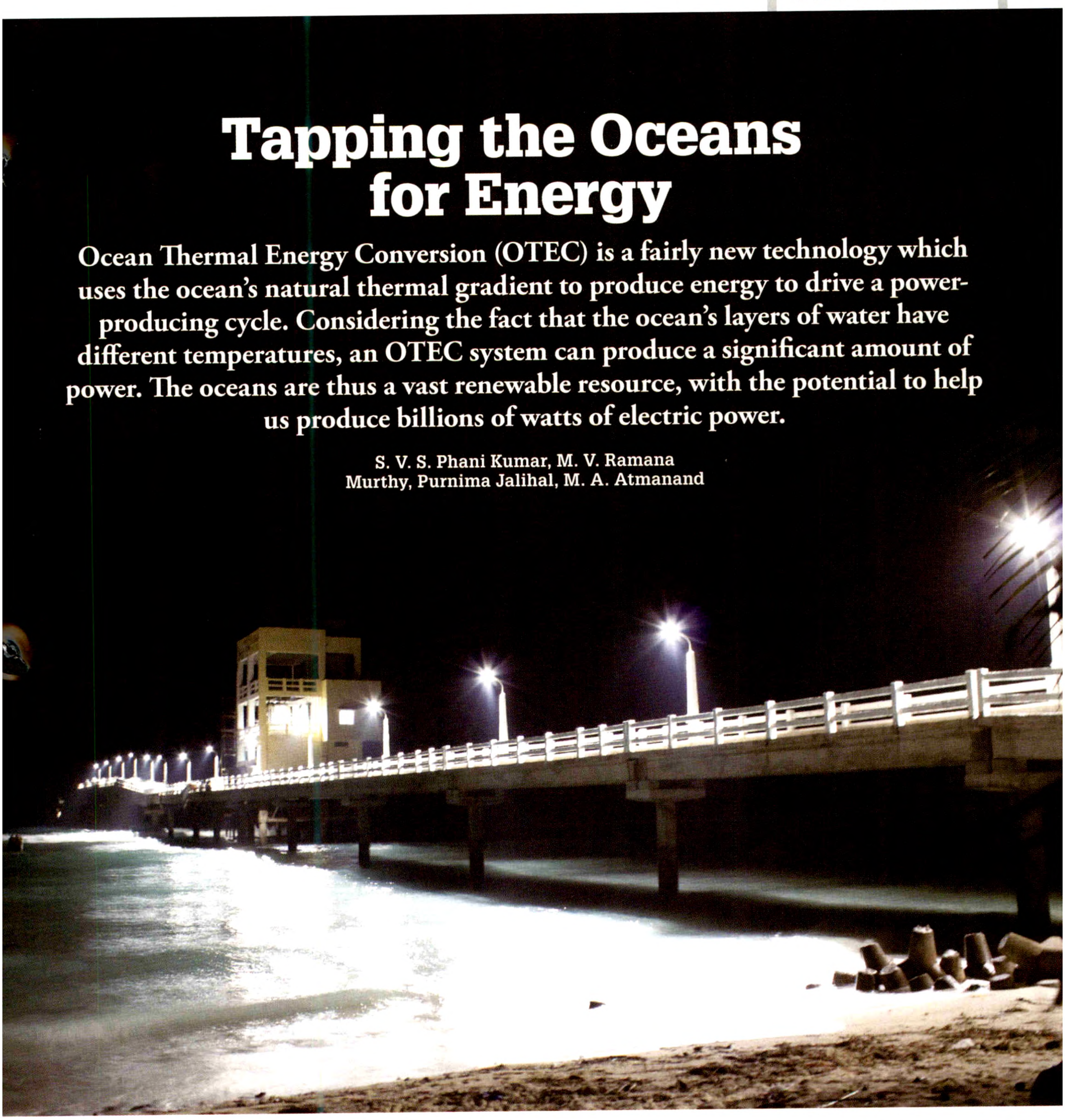
Tapping the Oceans for Energy

Ocean Thermal Energy Conversion (OTEC) is a fairly new technology which uses the ocean's natural thermal gradient to produce energy to drive a power-producing cycle. Considering the fact that the ocean's layers of water have different temperatures, an OTEC system can produce a significant amount of power. The oceans are thus a vast renewable resource, with the potential to help us produce billions of watts of electric power.

S. V. S. Phani Kumar, M. V. Ramana Murthy, Purnima Jalihal, M. A. Atmanand

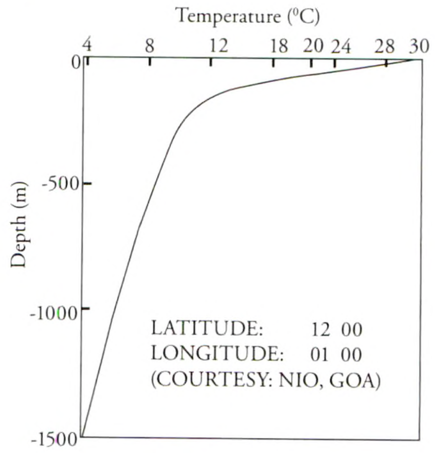


The modern world with all its technological advancements, needs power in large quantities today and the requirement is ever increasing. Therefore, the effort to tap renewable sources of energy is being attempted on a war footing. While solar, wind, biomass and other forms are already being tapped across the globe, energies which can be harnessed from the vast oceans is yet to move out from the research arena. Ocean energy can be harnessed in the form of waves, currents, tides and temperature gradients.

When watching waves break at a shore we can see the power they contain, the same power that causes havoc during a cyclone. Currents which are actually water velocities are also constantly present within the ocean bodies, though varying in magnitude and direction. While waves and currents contain a fair amount of energy, any structure or equipment to be mounted in the open sea needs to resist these forces to which it is subjected constantly, while generating power. Sea water is also very corrosive, hence materials used should be suitable for long term usage in the sea environment. Another factor is the location on the globe i.e. countries close to the equator have lower winds and wave intensities while those far away have very high wave climates. In India, the average wave power annually is low - though during the monsoon season, for a few months, the waves can be very high.

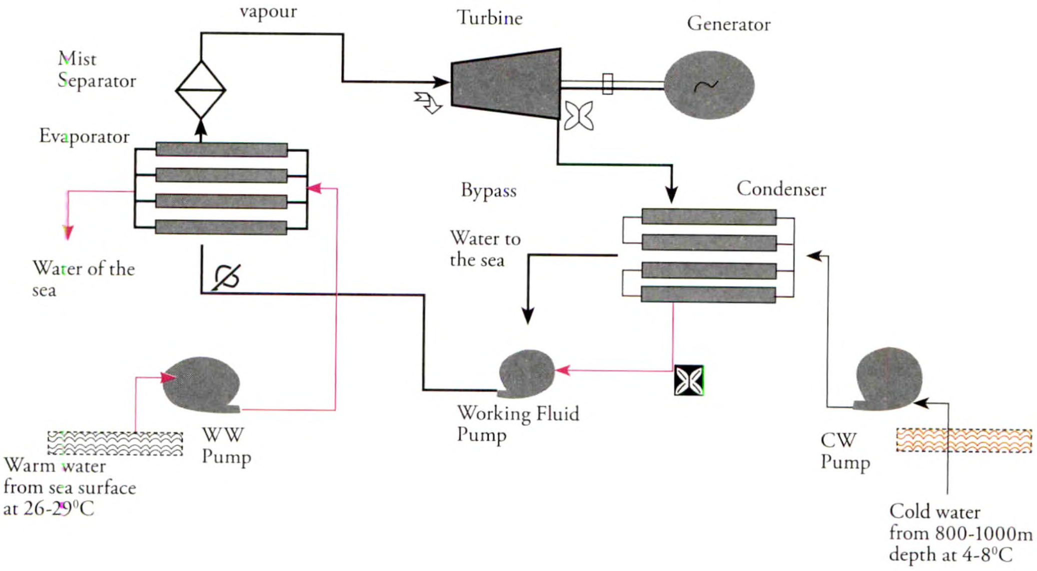
However being close to the equator and temperatures being high, the sea surface is always fairly warm. The ocean's temperature varies with depth as shown in Fig 1. The profile indicates that the temperature in around 1000m water depth could be as low as 6°C. This difference in temperature between the sea surface and at a deeper depth can be utilised to harness energy. This is called Ocean Thermal Energy Conversion or OTEC. Essentially in OTEC, a fluid with low boiling point is vapourised using the warm surface sea water. This drives a turbine connected to a generator which generates power. The vapour is condensed using the deep sea cold water and in a closed cycle goes back and gets vapourised again. This cycle runs continuously to generate power. Fig 2 shows the OTEC cycle. The main requirement of this process is large quantities of cold and warm sea water. While warm water is available all along the coastline, deep sea cold water is available only at depths of around 800-1000m. The sea bed near the coast drops very gently in India and hence the 1000m water depth is available only around 40-50 kms from the coast necessitating a floating OTEC plant. The OTEC method was attempted in the US and other countries a couple of decades ago, at the time of the oil crisis. Thereafter work was stopped for some years. Today again, many countries have realised that research on OTEC must be given priority.

Fig 1. Typical Profile of Ocean Thermal Gradient around the Indian Coast



The National Institute of Ocean Technology(NIOT), Chennai, decided to attempt setting up the first floating offshore OTEC plant of 1 MW off Tuticorin, in the year

Fig 2. A Schematic Diagram of the OTEC Cycle



2000. A schematic diagram of the OTEC cycle is shown in Fig 2. A floating plant needs the following complex systems:

- Power module components including heat exchangers and turbine.
- A floating platform with station keeping / mooring to position it in deep waters.
- A long cold water pipe to transfer large quantities of cold water from the depth to the surface.
- Offshore logistics.

All the above systems are facing severe technological challenges, which have not yet been tackled completely. These are briefly discussed below:

Firstly, heat exchangers have to be made of a material suitable to a combination of sea water and a working fluid like ammonia. The design needs to be optimised since the efficiency of the process is low. Using a material like titanium will cause the cost of the heat exchangers to be alone around one-third the capital cost. Thus newer materials also need to be explored.

A big challenge is the floating platform, which has to not only house the power module and plant but has to have good sea keeping characteristics to act as a stable platform throughout the year. Thus, studies towards its responses to severe environmental conditions become important. The OTEC plant's station keeping or mooring is also an important aspect. The most complex and challenging component is the large cold water pipe for continuous pumping of cold deep sea water for condensing the working fluid. This conduit has to withstand not only the environmental conditions during operations but its assembly and installation are extremely critical.

> **The use of LTTD with ocean thermal gradient also results in an environmentally friendly technology because of its use of naturally available heat in the process.**

To attempt to understand the challenges, a non self-propelled barge was built specially for this purpose at the plant off Tuticorin. All components of the power module were designed, fabricated, assembled and installed on the barge. Parallelly a 1 km long pipe with a diameter of 1 m made of HDPE (high density polyethylene) was assembled with the necessary connections at the Tuticorin Port. The pipe was towed around 40 kms off the coast to a deep water location.

However due to lack of suitable infrastructure and handling equipment, there were failures in the cold water pipe deployment. It was therefore decided to attempt desalination using the temperature gradient at shallower waters less than 500 m using the Low Temperature Thermal Desalination (LTTD) method. The process deals with evaporating the warmer surface sea water at low pressures and condensing the resultant pure vapour using deep sea cold water available at about 400m below sea level. The process is found to be simple and easy to maintain since

As part of the desalination projects, HDPE pipes of 630mm diameter and lengths of up to 950m were assembled, towed up to 10km and deployed to draw water from a depth of about 400m. Civil structures such as sumps weighing up to 500 tons and piers beyond breaker zone were cast in a lagoon, towed about 10 km to the other side of the island and were deployed at site. A bridge that connects the sump to the plant and shore was also constructed.

Fig 3. Configuration of a Barge Mounted Plant with Single Point Mooring

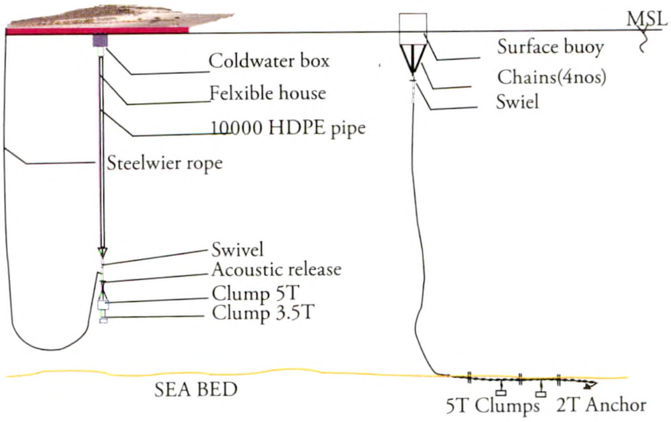
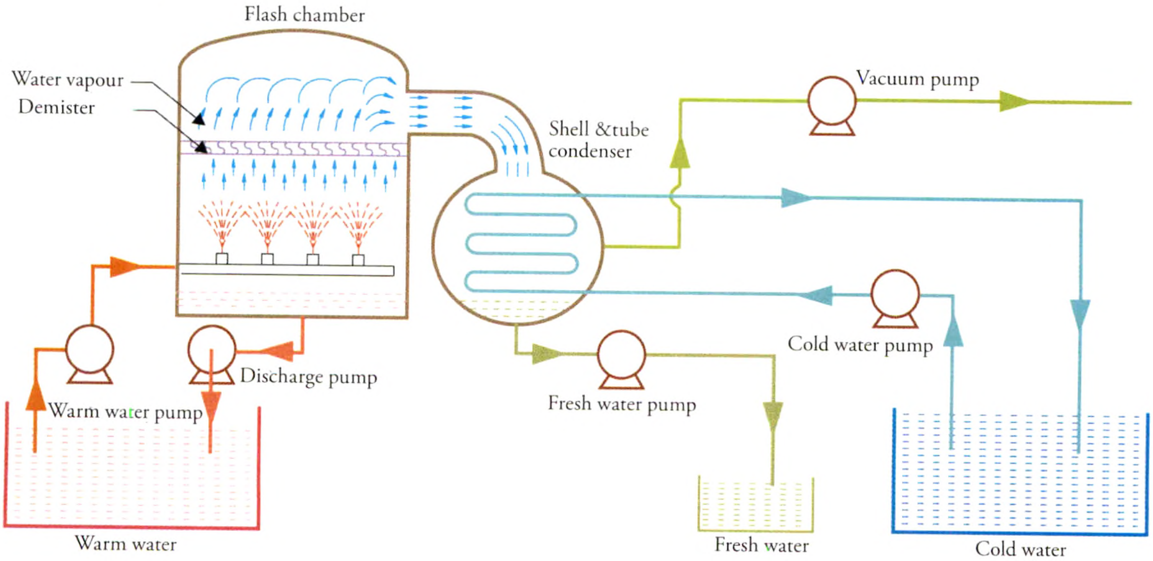


Fig 4. A Schematic Diagram of the LTTD process



An OTEC plant along with desalination would be an excellent source of clean and green energy and fresh water.

it requires just a few components such as a flash chamber for evaporation, a condenser for liquefying the vapour, sea water pumps, vacuum system, a long pipe to draw cold water from 400m below sea level, marine structures such as sump, plant building and the bridge. The use of LTTD with ocean thermal gradient also results in an environmentally friendly technology because of its use of naturally available heat in the process. A schematic diagram of LTTD process is shown in Fig. 4.

A pilot desalination plant with a capacity of 100m^3/day was established in the Kavaratti Island of Lakshadweep. The NIOT maintained the plant for one year and handed it over to the local PWD in 2006, which continues to maintain the plant till date. The NIOT put up similar plants in the region and two more plants, in Agatti and Minicoy Islands, each with a capacity of 100 cu m/day that started operations in 2011.

The OTEC barge was also used to demonstrate offshore desalination, where cold water is obtained from about 550m depth using a 700m long and 1m diameter pipeline. The NIOT has developed expertise in the design, assembly and deployment of cold water pipes. Efforts are on to design and build a large scale offshore desalination plant to serve mainland requirements.

Desalination, a spin-off of the OTEC cycle, has been successfully demonstrated. An OTEC plant along with desalination would be an excellent source of clean and green energy and fresh water. However the transfer of power to the shore over large distances to the mainland may not be feasible at this juncture and needs more technological development.

While the basic thermal cycle and the challenges in offshore installations are well understood today, there is a need to optimise the cycle and component design to increase the techno-commercial viability. Cold water from the depths also contains many nutrients and is good for mariculture. Possibility of extraction of some rare earth elements from the large volumes of water is also being studied.

Though the technological challenges are many and demonstration of OTEC for larger ratings is yet to be completed, the country must strive to harness this form of energy due to the large coastline and tropical water temperatures available. This is one of the endeavours being pursued by the NIOT towards the alleviation of the power deficit. ✪

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Biogas
Bottling in India

Today's fast paced world is overly dependent on energy to fulfill its various requirements related to daily life. Biogas, a clean and renewable source comes as an efficient and cost effective method to generate power. This case study of a biogas bottling plant showcases the efforts of the Ministry of New and Renewable Energy to usher in new technological breakthroughs in the arena of renewable energy.

M. L. Bamboriya

Energy is the key input for the socio-economic development of any nation. Industrialisation, urbanisation and mechanised agricultural techniques have generated a high demand of energy in all forms i.e. thermal, mechanical and electrical. To meet this ever-increasing demand, fossil fuels such as coal, oil and natural gas have been exploited in an unsustainable manner. This exploitation has been posing serious environmental problems such as global warming and climate change. While we have shortage of energy and are dependent on imports in case of petroleum, we are blessed with plenty of natural sources of energy such as solar, wind, biomass and hydro. These sources are environmentally benign and non-depleting in nature and are available in most parts of the country throughout the year.

Biomass resources such as cattle dung, agriculture wastes and other organic wastes have been one of the main energy sources for mankind since the dawn of civilisation. There is a vast scope to convert these energy sources into biogas. Biogas production is a clean, low carbon technology, useful for the efficient management and conversion of organic wastes into clean renewable biogas and organic manure/fertiliser. It has the potential for leveraging sustainable livelihood development as well as tackling local and global land, air and water pollution. Biogas obtained by anaerobic digestion of cattle dung and other loose and leafy organic matter/ biomass wastes can be used as an energy source for various applications namely, cooking, heating, space cooling / refrigeration, electricity generation and gaseous fuel for vehicular application. Based on the availability of cattle dung alone from about 304 million cattle, there exists an estimated potential of about 18,240 million cubic meter (m cu m) of biogas generation annually. The increasing number of poultry farms is another source which can generate biogas of 2173 m cu m annually with 649 m birds. In addition, kitchen waste from institutions, universities, restaurants, *baraat ghars*, industries, parks and gardens in urban and semi-urban areas and even non-edible de-oiled cake from Jatropha and other plants offer a very large potential. These wastes must be treated to ensure reduction in methane emission affecting climatic change and for better environmental conditions. In addition to gaseous fuel, biogas plants provide high quality organic manure with soil nutrients which in turn improves soil fertility, a must for sustainable production and for enhancing productivity. Thus, there is a huge scope for the installation of medium size biogas plants in the country. This can be translated to an aggregated estimated capacity of 8165 MW per day power generation or 22,06,789 LPG cylinders and 21304 lakh kg of urea equivalent or 3974 lakh tonnes of organic manure / fertiliser per day.

Fig 1. The schematic diagram of the BGFP project installed at Anand Energy, Vill.- Kalatibba, Teh.- Abohar, Dist.- Ferozepur (Punjab)

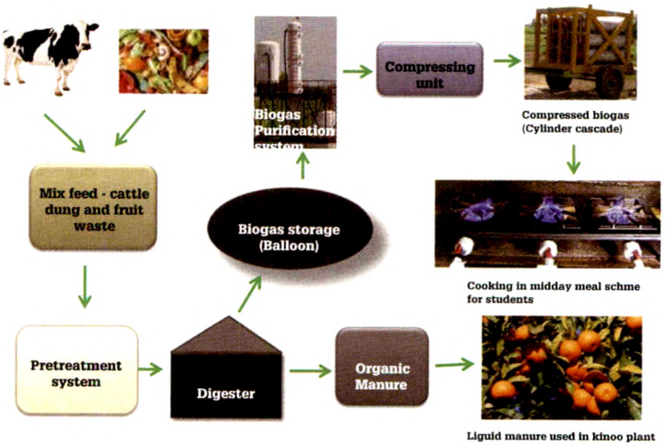
Biogas Purification system
Compressing unit
Compressed biogas (Cylinder cascade)
Mix feed - cattle dung and fruit waste
Biogas storage (Balloon)
Cooking in midday meal schme for students
Pretreatment system
Digester
Organic Manure
Liquid manure used in kinoo plant

Table 1. The salient features of BGFP project installed at Anand Energy, Vill.- Kalatibba, Teh.- Abohar, Dist.- Ferozepur (Punjab).

Particulars	Description	Remarks
Quantity processed	12 MT	Cow dung, Kinoo waste etc.
Biogas generated	600 NM^3	
Purified/Upgraded Biogas	324 NM^3	
Purified Biogas	231 kg	
Purified/Upgraded Biogas Filled in Cylinders at 150 bars	27 Cylinders of 8 kg each filled.	Equivalent to Rs. 10,800 of commercial LPG
Slurry / Manure	11000 Litres/day	Used as liquid fertilizer substituting chemical fertilizer worth Rs. 5,500/-

Biogas comprises of 60-65 per cent methane (CH$_4$), 35-40 per cent carbon dioxide (CO$_2$), 0.5-1.0 per cent hydrogen sulphide (H$_2$S), and the rest is water vapour etc. It is almost 20 per cent lighter than air. Biogas, like liquefied petroleum gas (LPG) cannot be converted into liquid under normal temperature and pressure. However, after extracting carbon dioxide, hydrogen sulphide and moisture and compressing it into cylinders, it can be made easily usable for transport applications and for stationary applications. Already, compressed natural gas (CNG) technology has become easily available and therefore, bio-methane (or enriched biogas) which is similar to CNG, can be used for all applications for which CNG is being used. Moreover, purified/enriched biogas (bio-methane) has a high calorific value in comparison to raw biogas.

During the year 2008-09, a new initiative was taken up for the demonstration of the integrated technology-package, in entrepreneurial mode, for installation of medium size mixed feed biogas fertiliser plants (BGFP) for generation, purification/enrichment, bottling and piped distribution of biogas under the Research, Development, Demonstration and Distribution (RDD&D) policy of the Ministry of New and Renewable Energy (MNRE). Such plants, when installed are expected to produce compressed biogas (CBG) of CNG quality standards so as to be used as vehicular fuel in addition to meeting stationary and motive power and electricity generation needs, in a decentralised manner through the establishment of a sustainable business model in this sector. These medium size biogas-fertiliser plants can be set up in various villages, agro / food processing industry zones among other areas of the country. Under the demonstration phase, the Ministry is providing financial assistance for implementation of a certain number of such projects that are following an entrepreneurial mode. So far 21 BGFP projects with an aggregate capacity of 37, 016 cu m/day have been sanctioned in ten states - Chhattisgarh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and Rajasthan.

The main components of BGFP are given below:

- Pre-treatment system;
- Biogas generation system;
- Biogas storage system;
- Biogas purification system
- Biogas bottling system;
- Slurry handling system.

The first biogas bottling project was sanctioned to Ashoka Biogreen Pvt. Ltd, after obtaining the license for filling and storage of compressed biogas in CNG cylinders from Petroleum and Explosives Safety Organisation (PESO), with a capacity of 500 cu m/day at village Talwade, Nashik (Maharashtra) which was commissioned on 16 March 2011. The second biogas bottling project of 600 cu m/day capacity for generation, purification/enrichment, bottling of biogas was sanctioned by the MNRE for Rs. 45.5 lakh Central Financial Assistance (CFA) during the year 2009-10, to Anand Energy at Kalatibba, Ferozepur, Punjab (Fig 1, Table 1). This was commissioned on 17 November 2011 after obtaining required license from the PESO. The biogas generation capacity of the plant is 600 cu m per day. The purity of biogas is about 98 per cent methane and this has been corroborated through tests conducted by the National Accreditation Board for Testing and Calibration Laboratories (NABL). The gas has been compressed to 150-bar pressure for filling in cylinders. This purified biogas is equivalent/similar to CNG.

> **The increasing number of poultry farms is another source and can generate biogas of 2173 m cu m annually with 649 m number of birds.**

The upgraded biogas is being filled in CNG cylinders and supplied to support the mid-day meal scheme for cooking food for over 18000 school students in Abohar and its adjoining areas. The slurry of the biogas plant is being sold to farmers to be used as a liquid manure for *kinoo* plantations. Field trials have indicated the excellent growth in agro-production and substantial improvements in quality. Further, minimum dropping off of fruits was reported since the use of biogas slurry as manure.

This biogas bottling project is projected to replace fuel and manure worth Rs. 40 lakh annually, recovering the full cost of the project within four to five years. The separation and bottling of CO_2 and extraction of humic acid from the slurry would further improve viability of biogas bottling plants. The BGFP provides three-in-one solution of gaseous fuel generation, organic manure / fertiliser production and wet biomass waste disposal. The leftover slurry is useful as organic manure / fertiliser for improving soil-fertility. It is non-polluting because it is free from weed-seeds, foul smell and pathogens. It is rich in nutrients such as nitrogen, potassium and sodium (NPK)and micronutrients - iron and zinc. These plants prevent black carbon emissions commonly seen in biomass *chulhas*. Biogas is an easy and healthy cooking fuel since methane emissions from untreated cattle dung and biomass wastes can also be avoided. The enriched biogas can be bottled in CNG cylinders and used wherever CNG is being used. Since there is no pollution from biogas plants, these are one of the most potent tools for mitigating climatic change and being earth saviours. ✪

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Biogas Plant for a School

An outstanding effort to generate power from a Biogas Power Plant in a residential higher secondary school which has helped this sizeable institution meet its everyday needs from cooking to generating power for running various machines.

This is the story of a residential higher secondary school run by the Sharda Vihar Jan Kalyan Samiti (SVJKS), situated at Sharda Vihar, Mindori village near Kerwan Dam, Bhopal. There are 584 students and around 100 teachers and staff members residing in the campus of the school. In a centrally located mess near the hostels, everyday, around 4500 to 5000 *chapatis* are prepared using biogas as the cooking fuel. The distance of the biogas burners in the kitchen, from the improved Khadi and Village Industries Commission (KVIC) biogas plant installed near the *goshala* is around 200 m. A high density polyethylene (HDPE) and galvanised iron (GI) pipe line measuring about 250 m has been used to deliver the gas in the mess, the gen-set room and the pharmaceutical lab of the Go-Vigyan Anusandhan Kendra.

Installation and Commissioning of the Plant

This biogas plant was installed and commissioned under the technical guidance of B P Gupta, MTech, MANIT, with financial assistance from the MNRE, New Delhi, disbursed through the MP Urja Vikas Nigam Ltd. Bhopal and SVJKS Bhopal in July 2001. To begin with around 35 Gir breed cows were brought from Gujarat to the *goshala* named Kamdhenu. The Go-Vigyan Anusandhan Kendra is now home to as many a 90 very healthy cows and 60 calves, all of the Gir variety. It also has around 200 old animals and 10 bullocks. More than 2 to 2.5 tonnes of dung and 10 to 20 kgs of fodder waste and cow urine as per requirement are collected from here, in addition to the production of milk per day.

Capacity of the KVIC biogas plant is 45 cu m. Everyday, input slurry made from 12-14 quintals of cow dung with equal quantity of water is fed through the inlet chamber to the digester of the biogas plant. Biogas so produced is used for preparation of *chapatis*. It saves about 2 cylinders of LPG each day. In fact this plant is overfed as far as daily slurry feeding is concerned.

The plant has been running successfully from July 2001. It was overhauled in June 2009 as accumulation of silt/mud in the digester with input slurry caused a reduction in the retention time of the input slurry. The problem was sorted out by emptying the digester completely. Such reduction in retention time of the input slurry can cause release of partially digested effluent slurry. Black epoxy paint has

been used to paint the gasholder and central guide frame to remove the rust patches and protect the gasholder surface from ill effects of weathering.

Salient Features of the Plant

Rust Prevention: Rust proofing is done by a water jacket around the digester using lubricating oil / greasing oil that is placed over water surface. This is also for eliminating direct contact of the gas holder with input slurry.

Rain Water Draining from Water Jacket: Siphon arrangements have been made for removing the rain fed water from the top of the gas holder to the water jacket so that lubricating oil in the jacket remains undisturbed.

Provision of Overhead Beam: Overhead beam structure has been provided for lifting the gas holder out of the digester for regular maintenance of the plant, providing gas delivery through the central guide pipe, free revolving and vertical movement of the gas holder.

Enhancement of the Life of the Central Guide Frame and Gas-holder:

- Strengthening of central guide frame for increasing its life by putting reinforcement cement concrete between central guide mild steel (MS) pipe and delivery GI pipe which is concentrically fitted inside the central guide pipe.
- Delivery of biogas through the central guide frame by carrying a GI pipe through central guide pipe and taking it out along one of the I-sections of the cross at the ledge level of the digester for easy moisture removal and eliminating the requirement of about 9 m flexible pipe bi-annually.
- Provision of scum breaking by vertical mild steel members of gas holder and ensuring its free revolving motion and vertical movement.

> **In a centrally located mess near the hostels, every day lunch and dinner with around 4500 to 5000 chapatis are prepared by making use of biogas as cooking fuel.**

Additional Gas Storage Capacity: An additional gas storage capacity to avoid wastage of biogas during morning hours until the beginning of food preparation in the kitchen, when the gas holder of the plant is fully raised and is full of gas.

Utilisation of Additional Biogas if Available: Charging of a 9.5 kVA dual fuel (diesel+biogas) gen-set for electricity generation at the time of load shedding, is done. During vacations in the institute, the biogas is utilised for the production of medicines using 100 cu ft per hour biogas burners.

Bio-manure Production: Manure drying pits have been constructed in adequate number to maintain the drying cycle of the effluent slurry from the digester. So that regular production and storage, packing and supply is maintained. Production of additional manure by processing waste fodder of the *goshala* through vermiculture is regularly carried out. This plant by now has completed more than 10 years and 6 months of its continuous and successful operation and yet it is as good as new. On the basis of its present condition, it can be predicted that it would complete more than 25 years before becoming defunct.

The two reasons for the success are (i)Proper implementation of biogas technology being disseminated by Ministry of New and Renewable Energy, New Delhi and (ii)the sincere efforts of Hukum Singh Patidar, the Manager of the Institute. ❂

TEDA's RENERGY 2012

A Stupendous Success

The Tamil Nadu Energy Development Agency (TEDA) organised a two-day international conference and exhibition on renewable energy. RENERGY 2012 was held at the Chennai Trade Centre, Nandambakkam, on 12 and 13 March 2012. The Conference was inaugurated by the Minister for Electricity, Prohibition and Excise, Natham R Viswanathan, in the presence of G B Pradhan, Secretary, Ministry of New and Renewable Energy (MNRE); Ramesh Kumar Khanna, Principal Secretary, Energy Department, Government of Tamil Nadu, Rajeev Ranjan, Chairman, Tamil Nadu Electricity Board, Sudeep Jain, Chairman and Managing Director, TEDA and other senior government officials from the centre and state, to debate, discuss and explore several avenues in this sector.

The conference had over 1300 delegates, with a significant number from abroad, making it the largest renewable energy conference ever held in the country. It was aimed at creating a unique experience for all industry leaders to come on one platform to discuss the various investment opportunities, potential and scope in solar, wind, biomass and newer waste-to-energy technologies, electric vehicles, batteries and other energy efficiency sectors. The exhibition had over 100 companies from all sectors of renewable energy participating in it. Leading companies and organisations included Zynergy, Suzlon, Gamesa, Sun Edison, ReGen Power, Centre for Wind Energy Technology (CWET), Vestas, Bonfiglioli, Greenpeace and others who participated in the exhibition, which attracted over 7500 visitors, making it the largest attended renewable energy exhibition in South India.

The conference hosted talks by leaders and top bureaucrats including Dr Pramod Deo, Chairman, Central Electricity Regulatory Commission (CERC); Satnam Singh, CMD, Power Finance Corporation Ltd.; Abha Shukla, Secretary, Bureau of Energy Efficiency; NS Prasanna Kumar, MD, Karnataka Renewable Energy Development Limited (KREDL); DP Joshi, Director, Gujarat Energy Development Agency; Debashish Majumdar, Chairman and Managing Director, The Indian Renewable Energy Development Agency (IREDA); Anil Agrawal, CEO, NTPC Vidyut Vyapar Nigam Ltd. (NVVN); Dr Gomathinayagam, Executive Director, CWET and Ashok Avasthi, Executive Director, Rural Electrification Corporation Ltd. (RECL) and many others. Commenting on the conference N R Viswanathan, Electricity Minister of Tamil Nadu said: "RENERGY 2012, we believe will spearhead Tamil Nadu's growth in the renewable energy sector and open more investment opportunities for new players. We are expecting it to lay a strong foundation for the industrialists and public to understand where we are heading. Tamil Nadu is a leader in wind energy and thanks to the Chief Minister of Tamil Nadu, J Jayalalithaa's vision, we will soon overcome all bottlenecks." ✪

RE and Energy Conservation-2011

In the financial year 2011-12 with the support of the Ministry of New and Renewable Energy (MNRE), the Maharashtra Energy Development Agency(MEDA) organised 3 State level seminars and exhibitions at regional headquarter cities namely Aurangabad, Nagpur and Navi Mumbai. The purpose was to make the people aware about the use of renewable energy and the status and scope of renewable energy at the national and state level. These events really boosted the efforts of the MEDA and the MNRE in creating awareness about the use of renewable energy. The theme of the event was Renewable Energy and Energy Conservation -2011.

Aurangabad

Exhibition and Seminar

(14 – 16 October 2011)

The exhibition was held in the grounds of Hotel VITS with a total of 40 well furnished free stalls put up. The entry was free and it was visited by more than 40,000 persons. There was an attractive live demo of projects and renewable energy gadgets were put up for sale. Ganesh Naik, Minister, Non-Conventional Energy, Maharashtra inaugurated the function.

A one- day seminar on Renewable Energy and Energy Conservation-2011 was held on 14 October 2011. More than 300 participants including students from technical and engineering colleges, architects, builders, investors, engineers and others from various industries attended the seminar.

Nagpur

Exhibition and Seminar

(25 – 27 November 2011)

An exhibition was held at the Kasturchand Park Ground, Nagpur with 60 stalls put up for display. It attracted more than 45,000 visitors. Shivajirao Moghe, Minister, Social Justice, Maharashtra inaugurated the function.

A one-day seminar was organised on 25 November 2011 at Hotel Tuli International, Nagpur on 'Solar Energy Applications and Solar Passive Architecture' with more than 350 participants from technical and engineering colleges, architects, builders, investors, engineers and among others from various industries.

Navi Mumbai

Exhibition, Seminar and EC award distribution ceremony

(13 – 15 March 2012)

The exhibition was held at Corporation Ground, Navi Mumbai where a total of 70 stalls were put up and it was attended by more than 45,000 visitors. Ganesh Naik, Minister, Non-Conventional Energy, Maharashtra inaugurated the function.

Along with the exhibition a one-day seminar was held on 13 March 2012 at hotel Four Points, Vashi, Navi Mumbai, on the theme 'Power Generation from Renewable Energy Projects and Energy Conservation' with the participation of around 450 people. A state level Energy Conservation Award distribution ceremony was also organised along with the event. The Thane and Pune Municipal Corporations were given the EC award by Ganesh Naik. Apart from these many other private units were also rewarded for their efforts in the field of energy conservation.

Various companies like manufacturers of solar PV and thermal gadgets, batteries, biomass gasifiers, wind power developers and manufacturers, energy consultants and auditing firms participated in the exhibition. It was also attended by a varied audience ranging from industrialists, and builders to officers, doctors, social organisations and students. The event proved helpful for the people in Marathwada and Vidarbha regions, who appreciated the MEDAs efforts in making renewable energy and energy conservation devices and systems available under one roof and at their doorstep. Expert speakers elaborated upon the importance of the sources of renewable energy and energy conservation and the policies of state and central government. Many manufacturers, developers, distributors, dealers got a good platform for presenting their products to people. ❂

Hydrogen Power in Everyday Life: Clean and Energy Efficient

Ich fahre mit Wasserstoff
sauber - sicher - zukunftsorientiert
H2
BUCHER

Since 2009, a hydrogen powered street cleaning vehicle has been undergoing testing on the streets of Basel, Switzerland. The project is intended to take 'hydrogen' drives out of the laboratory and onto the streets in order to gain experience on using them under practical conditions. The result of the pilot trial: hydrogen as a fuel for municipal utility vehicles saves energy, is environmentally friendly and is technically feasible. In order to make it cost-effective, however, the prices of fuel cells, pressurised storage tanks and electric drives must all drop significantly.

The hydrogen powered street cleaning vehicle, took about 18 months to develop. "It became clear relatively quickly that the fuel cell system, which had been developed as a one-of, specially for the project, was not yet ready for use in a real-life setting," explains project leader Christian Bach, head of Empa's Internal Combustion Engines Laboratory. The vehicle has achieved its targets both in terms of energy consumption and performance, the project team -- which, in addition to researchers from Empa and the Paul Scherrer Institute (PSI), also included the vehicle manufacturer Bucher Schoerling, the electric drive specialist Brusa, the hydrogen manufacturer Messer Schweiz, and the city of Basel Environment and Energy Department as well as the city's cleaning services -- decided to replace the fuel cell system initially used with another more mature product, and also to implement a single centralised safety module. The 'Fuel Cell System Mk 2' has now been in operation since the summer of last year and has proven to be far more robust; in fact, only once has it been necessary to take the vehicle out of service, because of a defective water pump.

Despite these setbacks, however, for the past three months, the vehicle has been running so reliably that the city cleaning services are able to use it on an everyday basis as they would a 'normal' vehicle.

The test phase in Basel showed that fuel cells are ready for use under everyday conditions, though currently only in niche applications such as municipal utility vehicles. Their use allows the operator to save a considerable amount of energy, since the vehicle consumes less than half the fuel of its contemporaries. This means that instead of 5 to 5.5 litres of diesel per hour (equivalent to an energy consumption of 180-200 MJ per hour) the hydrogen powered vehicle needs only 0.3 to 0.6 kg of fuel per hour (that is, 40-80 MJ per hour). And in terms of CO_2 emissions, too, the new vehicle performs about 40 per cent better than a diesel powered equivalent, even when the hydrogen is produced by the steam reforming of natural gas using fossil fuels. If the hydrogen was produced using energy from renewable sources then the CO_2 reduction would be even greater. During use, the novel vehicle has proven to be user-friendly and safe. Refuelling was done by the drivers themselves at a mobile, easy-to-use hydrogen fuel station. An additional advantage is the fact that the fuel cell powered vehicle is much quieter than a diesel vehicle. The only disadvantage, however is, that on cold days, the waste heat from the fuel cell and the electric motor are not sufficient to adequately warm the driver's cabin -- a typical weakness of electrical drives. The vehicle will undergo further testing in everyday situations in order to gain more operating experience and to allow the ageing behaviour of the various components used in the vehicle to be studied. Currently a vehicle of this kind is about three times as expensive as a conventional one. On the other hand, it is encouraging to know that the costs of fuel cell systems alone have, over the past few years, dropped by a factor of ten, and the end of this trend is not yet in sight. ✪

ELECTRICITY WITH A MAGNET

Of course you know how a magnet can pick up small metal objects. You can actually make a tack jump to the magnet by holding them close together. Magnetism is a form of energy. It can push or pull things. It can even push or pull some of the tiny particles that make up matter: electrons. And when you push or pull electrons, you get electricity. Let's try making electricity with a magnet.

STEPS

1. Wind the wire around the cardboard tube about 20 times

2. Connect both ends of the wire to the meter.

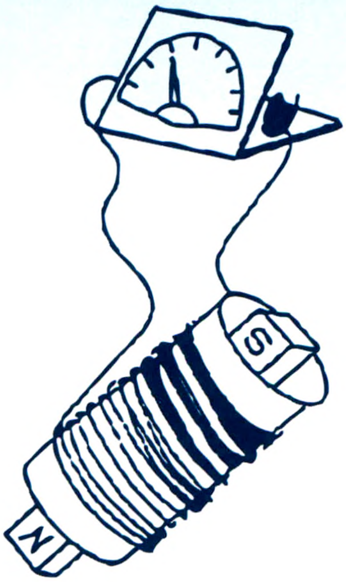
3. Take the magnet and move it near the coil but not through it. Observe the meter.

4. Move the magnet in various directions around the coil.

5. Move the magnet through the coil, back and forth. Make more than one trial doing this. Try moving the magnet at different speeds. Move the coil over the magnet, keeping the magnet still.

Things you will need

- 100 cm of bare copper wire
- 1 bar magnet
- 1 electric meter
- 1 cardboard tube



NOW ANSWER THE QS

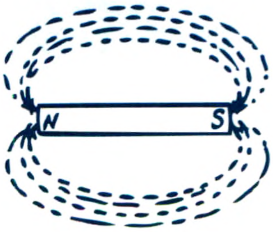
1. In which step did the meter move the most?

2. When the meter made the greatest movement, in what direction were you moving the magnet?

3. Was there a difference between moving the magnet through the coil, or moving the coil over the magnet?

4. Was there a difference when you moved the magnet faster?

5. The lines of force on a magnet would look something like this (if we could see them). What happened to those force lines when you moved the magnet inside the coil?



6. Can you figure out some way that you could make the magnet spin really fast inside the coil?

Send your answers to the Editor and see your name specially flashed on this page.

Source : www.ehow.com

Website

Ecars in Ireland

www.esb.ie

ESB established ecars to roll out the charging infrastructure for electric cars and vehicles across Ireland and to support the introduction and demand for electric cars nationally.

ESB, as the single owner/operator of the electricity distribution system, is responsible for implementing this across Ireland. ESB ecars' targets are to install 2,000 home charge points, 1,500 public charge points and 30 fast charge points nationwide.

Renewable Energy World Conference & Expo Africa

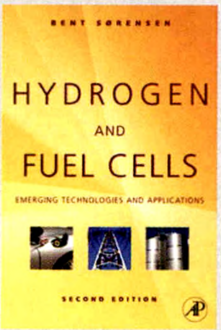
ww.renewableenergyworldafrica.com

Renewable Energy World Africa Conference and Exhibition 2012, taking place in Johannesburg, South Africa on 6-8 November 2012, have launched their eagerly anticipated website. The website contains important information regarding to exhibiting and sponsorship opportunities, travel and accommodation for the event, registration prices, etc.

Alternative Fuel Vehicle Resale website

www.afvresale.com

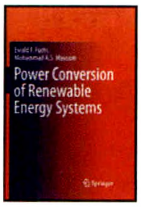
The Sales Network (TSN), a provider of niche-marketing solutions, released a new website, designed to aid customers looking to buy and sell previously owned alternative-fuel vehicles and equipment, according to a **March 6, 2012** press release. The site provides free membership for listing, responding and searching for pre-owned alternative-fuel vehicles in the US, including those powered by propane autogas, ethanol, CNG, electricity and biodiesel, as well as hybrid vehicles.



Hydrogen and Fuel Cells:
Emerging Technologies and Applications

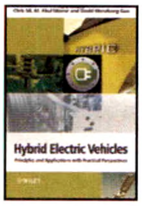
By: **Bent Sorensen**
Hard Cover: 512 Pages
Cost: $ 72.08
Publisher: Elsevier Ltd. 2011
ISBN: 978-0-12-387709-3

This book provides a brief ready reference for a hydrogen economy, in which this one gas provides the source of all energy needs and is often touted as the long-term solution to the environmental and security problems associated with fossil fuels. However, before hydrogen can be used as fuel on a global scale we must establish cost effective means of producing, storing, and distributing the gas, develop cost efficient technologies for converting hydrogen to electricity (e.g. fuel cells), and creating the infrastructure to support all this. This text available provides up to date coverage of all these issues at a level appropriate for the technical reader. The book describes the various aspects of hydrogen fuels cells usage along with the obstacles, benefits of its use and the social implications.



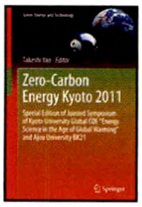
Power Conversion of Renewable Energy Systems

By: **Ewald F. Fuchs, Mohammad A.S Masoum**
Hard Cover: 692
Publisher: Springer 2011
ISBN: 978-1-4419-7978-0



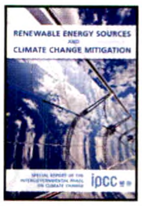
Hybrid Electric Vehicles: Principles and Applications

By: **Chris Mi, M. Abul Masrur, David Wenzhong Gao**
Hard Cover: 468 Pages
Cost: Euro 68.20
Publisher: John Willy & Sons Ltd 2011
ISBN: 978-04707477352011



Zero Carbon Energy Kyoto 2011

By: **Takeshi Yao**
Hard Cover: 300 pages
Cost: $ 163.17
Publisher: Springer 2012
ISBN: 978-4431540663



Renewable Energy Sources and Climate Change Mitigation

By: **Ottmar Edenhofer, Ramón Pichs-Madruga, Youba Sokona, Kristin Seyboth, Susanne Kadner, Patrick Matschoss**
Hard Cover: 1088 pages
Cost: $ 183.78
Publisher: Cambridge University Press 2012
ISBN: 978-1107023406

National

3 June 2012	International Conference on Power System Operation and Energy Managment Place: Hotel President, Guwahati Organiser: IIMT. Bhubaneswar Contact: Prof. Pradeep Kumar Mallick, +91 8895885152 or icpsoem, @gmail.com Website: www.interscience.ac.in
26 - 27 July 2012	REaction 2012 Place: Chennai, Tamil Nadu, India Organiser: Energy Alternatives India Contact: Karthik +91 9944667345 or reaction2012@eai.in Website: www.eai.in/reaction2012/
30 - 31 July 2012	PV Project Development India Summit 2012 Place: New Delhi, Organiser: Solar PV Insider Contact: +44 (0) 207 422 4307 or laura@pv-insider.com Website: www.pv-insider.com/development-india

International

18 - 22 June 2012	20th European Biomass Conference and Exhibition Place: Milano Congressi, Milan, Italy Organiser: European Commission Contact: +39 055 5002280 ext. 221 Website: www.conference-biomass.com
2-3 July 2012	EWEA Technology Workshop: Analysis of Operating Wind Farms Place: Lyon, France Organiser: EWEA - European Wind Energy Association Contact: Tim Robinson, +32 2213 1844, techworkshop@ewea.org Website: www.ewea.org/techworkshops
21- 27 July 2012	Energy Transition: Expansion and Integration of Renewable Energy Sources Place: Greifswald and Berlin, Germany Organiser: IKEM - Institute for Climate protection, Energy and Mobility Contact: Anika Nicolaas Ponder, + 49 (0) 30 4081870-10 Website: www.summeracademy2012.com
24- 26 July 2012	International Conference on Smart Grid Systems (ICSGS 2012) Place: Kuala Lumpur, Malaysia Organiser: International Association of Computer Science & Information Technology (IACSIT) Contact: Ms. Susan Zhang, icsgs@vip.163.com Website: www.icsgs.org/cfp.htm
25 - 27 July 2012	Clean Energy Week Place: Sydney, NSW, Australia Organiser: Clean Energy Council Contact: Madeleine Brennan +61 3 9929 4100 Brennan@cleanenergycouncil.org.in, info@cleanenergycouncil.org.au Website: www.cleanenergyweek.com.au

Renewable Energy at a Glance

Cumulative deployment of various renewable energy projects/systems/devices in India

Renewable energy programme/ systems	Cumulative achievements (as on 31 March 2012)
I. Power from renewables	**In MW**
A. Grid interactive power	
Wind power	17352.66
Small hydro power	3395.31
Biomass power	1150.10
Bagasse cogeneration	1985.23
Waste to power (urban and industrial)	89.68
Solar power (SPV)	941.28
Sub total (A)	**24914.26**
B. Off grid/captive power	
Waste to energy	101.75
Biomass (non-bagasse) cogeneration	382.50
Biomass gasifier (rural and industrial)	150.21
Aero-generators/hybrid systems	1.64
SPV systems (>1 kW)	85.21
Watermills/micro hydel	1877
Sub total (B)	**721.31**
Total (A+B)	**25635.57**
II. Remote Village Electrification (villages/hamlets)	**9160**
III. Other renewable energy systems	
Family type biogas plants (in lakh)	45.09
Solar water heating systems-collector area (million sq m)	5.46

kW= kilowatt; MW = megawatt; Sq m = square metre

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All this with a clear vision to be the most admired integrated enterprise.

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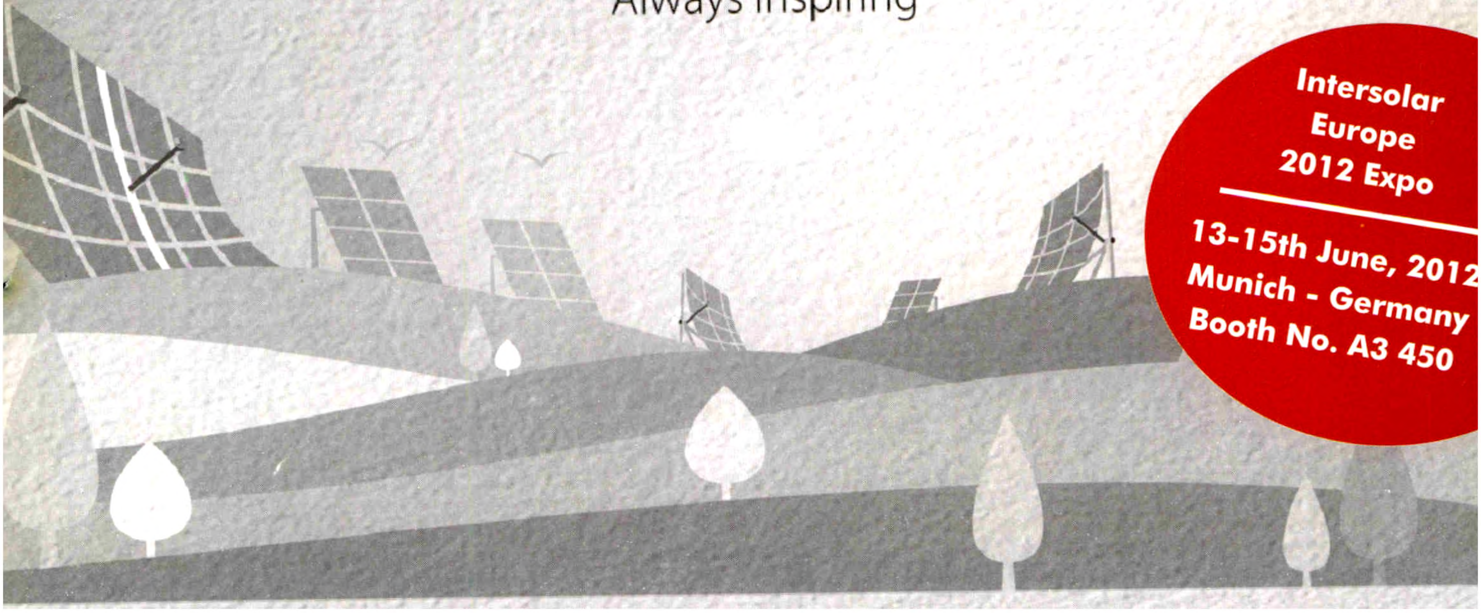
Always Inspiring



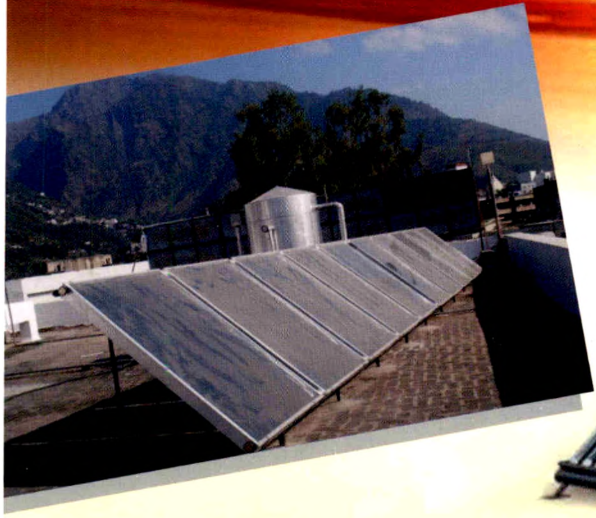
Intersolar Europe 2012 Expo

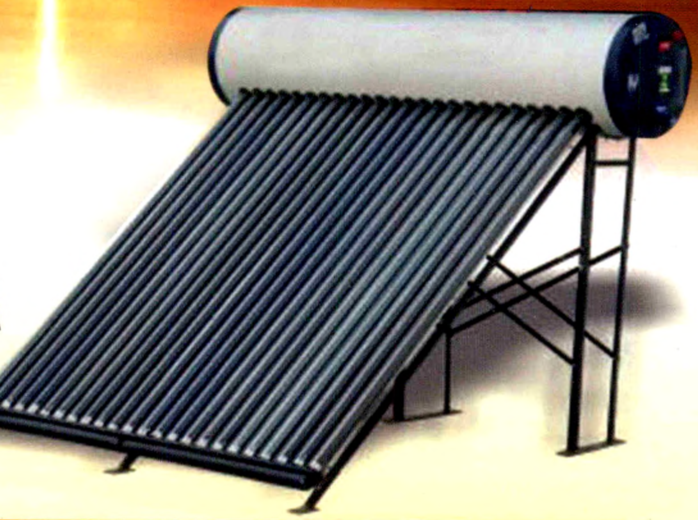
13-15th June, 2012
Munich - Germany
Booth No. A3 450

RNI No. DELENG/2007/22701

Solar Water Heater - an Ideal Choice

अक्षय ऊर्जा से देश विकास





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- **For installation & to avail subsidy / soft loan contact our State Nodal Agencies in state capitals/ Approved manufacturers/ Channel partners/ Banks/FIs participating in Scheme. Details available at our website: www.mnre.gov.in. Click at Solar Water Heater on home page or call Helpline No. 1800 233 4477 (Monday to Friday : 9.30 am to 6.30 pm, Saturday 9.30 am to 1.30 pm)**
- Please check quality and price before you buy. Wide range of products available. Guidelines on quality and selections for a system also available at website.

सत्यमेव जयते

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Renewable Energy

Akshay Urja

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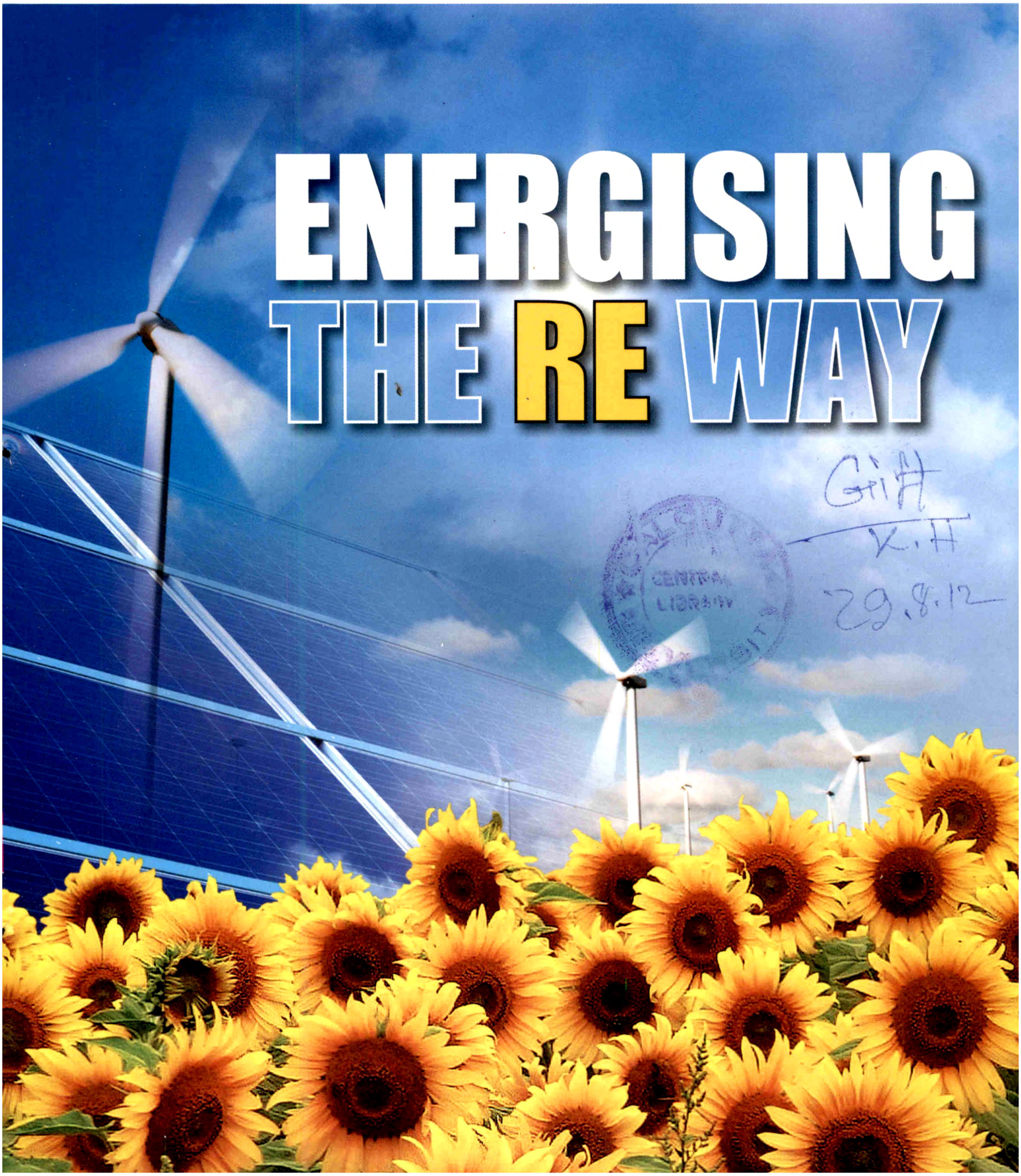

ENERGISING THE RE WAY

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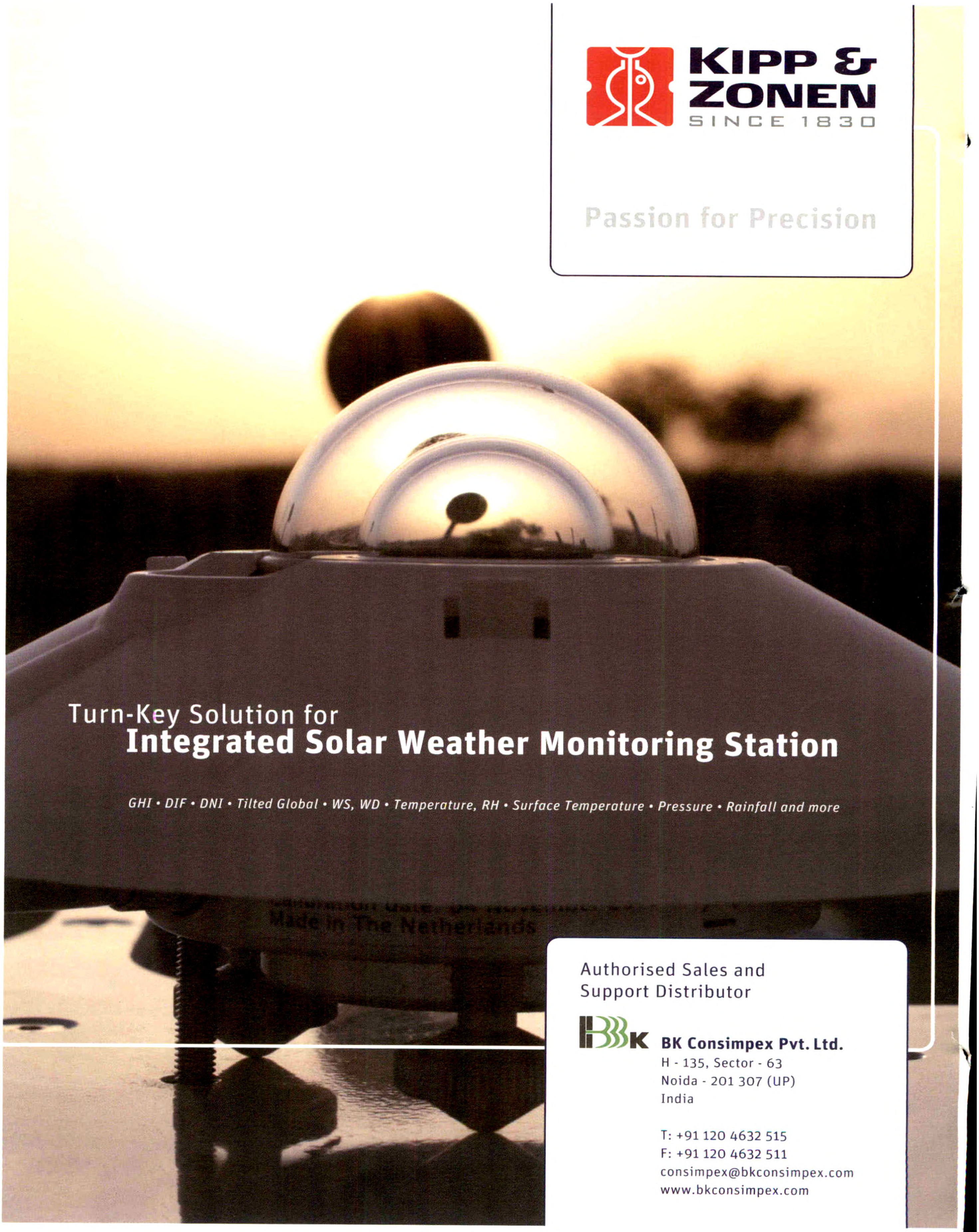

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Renewable Energy
Akshay Urja

Volume 5 ▪ Issue 6
June 2012

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Cover Photo: Collage depicting renewables for a vibrant future.

Disclaimer: The views expressed by authors including those of the editor in this newsletter are not

From the Editor's Desk

Dear Readers,

Science has played a stellar role in discovering the potential of renewable energy sources, like biofuel, geothermal, solar, wind and hydro and in making renewable energy usable for everything, from complicated processes to commonplace activities. Indeed the exploitation of renewable sources of energy is a path breaker, yet there is always scope for innovative technologies to make these sources affordable and user friendly.

We are all aware that renewable energy can play a vital role in mitigating the degradation of the environment. In fact renewable energy has already started making a visible impact in our country's energy mix. With a present installed capacity of over 25,000 MW of grid-connected renewable power, India today, stands among the top five countries of the world in terms of renewable energy capacity. Renewable power represents about 12 per cent of the total installed electricity generation capacity in India. The Ministry of New and Renewable Energy (MNRE) aims at accelerating the deployment of renewable energy with a target of around 30,000 MW of renewable power, by 2017. In January 2010, the MNRE launched the Jawaharlal Nehru National Solar Mission (JNNSM) and at present with the setting up of about 1,000 MW of solar power capacity, the first phase of the Mission is nearing completion.

Currently, though most residential societies, commercial establishments, institutions, markets etc., are still dependent upon diesel generating sets (gen-sets) to supply electricity as a backup during the non-availability of grid power, it is pertinent to note that today, the cost of solar electricity is cheaper than that of electricity generation from these diesel gen-sets. Hence it is worthwhile to supplement diesel based electricity with electricity from solar and other renewable sources.

This issue of Akshay Urja promises its readers a wealth of information on different renewable energy sources. It has contributions from people who have been involved with RE technology which is trying to bridge the gap between knowledge and the inspiring vision of setting the world free from its sole dependence on fossil fuels, and the glitches of pollution and environment degradation. The articles on India's wind power potential, small hydro power, geothermal energy, microalgae as potential biofuel source, biochar as a substitute for P-Fertilisers etc. will give the readers exciting insights into technology which is eco-friendly, enhancing efforts towards a cleaner, greener environment.

I wish all our readers a happy reading !

AKTripathi

ARUN K TRIPATHI
<aktripathi@nic.in>

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Letters to the Editor

I would like to subscribe to the magazine, Akshay Urja, as I am very passionate about solar energy and its impact. Also since it is published by the Ministry of New and Renewable Energy (MNRE), I feel that this would be the best medium of knowledge I can have.

Shivali Pandya Thakar
Borivali (W), Mumbai

I am working at the Renewable Energy Department, College of Technology and Engineering (CTAE), Udaipur. I always participate in *kisan melas*, exhibitions and demonstrations organised for *kisans*. I also assist students of B.E, M.E and Ph.D in their projects. I request you to kindly mail the Akshay Urja magazine regularly, so that everyone here may be benefited by the informative articles published in it.

Dinesh Kr. Agrawal
Udaipur, Rajasthan

I work as an Assistant Engineer (Electrical) with the Indian Institute of Science Education and Research, Bhopal, set up in 2008 by the Ministry of Human Resource Development, Government of India. The Institute is committed to imparting high moral and ethical values and creating concern for social and environmental issues.

I have been through the MNRE website and have visited the Akshay Urja bi-monthly newsletter page and have found this newsletter very scholarly and informative. The editorial of the newsletter is very insightful and the magazine's contents, quite impressive.

I would like to read all the newsletters as it will help enhance my knowledge about the latest technological advancements in the area of green energy development. I will be very grateful to you if you could mail me the newsletter.

Sachin Kumar Shandilya
Assistant Engineer (E)
IISER, Bhopal

With reference to the Akshay Urja magazine, I am very pleased to inform you that I have read the online version of the same in your portal and am very impressed by the magazine, as it covers all the aspects of renewable energy including the emphasis on setting up an enabling environment for solar technology penetration as well as biodiesel generation techniques etc. Our school has set up an 'eco club' to spread awareness and save the environment and towards this endeavour, the magazine will be very helpful in our future projects. I request you to oblige us by sending this mazagine.

Rajesh Kumar Chandel
Principal, Gyan Ganga,
International School , Jabalpur

I would like to introduce myself as an Assistant Manager (Environment) based in Kolkata. I am very interested in new and renewable energy sources and have found your magazine very informative and useful. I wish to subscribe to your magazine. Please let me know of the procedure and formalities for subscription.

Rohan Kumar Mahto
Kolkata, West Bengal.

I am very keen on subscribing to the Akshay Urja newsletter as it is packed with information and is very educative. Last month I got a copy of the previous issue of the magazine from my professor and it proved to be a great help in helping me prepare for my UGC project. Therefore, I request you to regularly send me a printed copy of this bi-monthly newsletter.

Dr. D. Raja Jebasing
Assistant Professo
Arachalur, Tamilnadu

मैं विकेश कुमार स्नातक द्वितीय वर्ष, सामाजिक संकाय काशी हिन्दू विश्वविद्यालय का छात्र हूँ। मुझे 'अक्षय ऊर्जा' पत्रिका प्राप्त हुई। इसके लिए मैं संपादक महोदय और 'अक्षय ऊर्जा' के सभी सहयोगियों को धन्यवाद ज्ञापन देना चाहता हूँ। पिछले अंक में बायोमास की महत्ता को ध्यान में रखकर काफी महत्त्वपूर्ण जानकारियां उपलब्ध कराई गयी है, भारत के विभिन्न राज्यों के क्षेत्रों में बायोमास ने अपनी सक्षम एवं सशक्त भूमिका अदा की है। पत्रिका में घरों के कूड़े–कचरे के नवीकरण की जानकारी काफी स्पष्ट एवं स्वीकार्य रूप में है। संपादक महोदय को आलेख काफी महत्त्वपूर्ण एवं रूचिकर है।

मैं संपादक महोदय से नम्र निवेदन करना चाहता हूँ कि मुझे 'अक्षय ऊर्जा पत्रिका की सदस्यता देकर प्रत्येक मासिक अंक को उपलब्ध कराने की कृपा की जाए। जिससे नवीकरणीय ऊर्जा के महत्त्व को सामरिक एवं सामुहिक दृष्टि से अन्य लोगों तक सफल रूप से पहुंचा सकूं। पत्रिका का अंक हिंदी माध्यम में हो, इसके लिए मैं संपादक महोदय का विशेष आभार व्यक्त करता हूँ।

'अक्षय ऊर्जा, सबके साथ
देश विकास, अपने हाथ'।

विकेश कुमार
सामाजिक विज्ञान संकाय
वाराणसी, उत्तर प्रदेश

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja will make every effort to make this newsletter highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in terms of content and presentation. **Editor: Akshay Urja**

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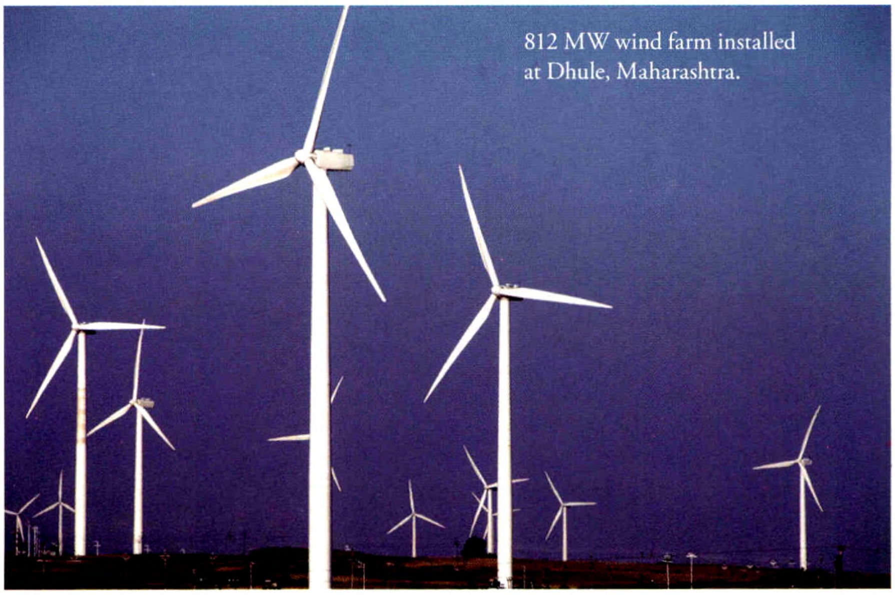

812 MW wind farm installed at Dhule, Maharashtra.

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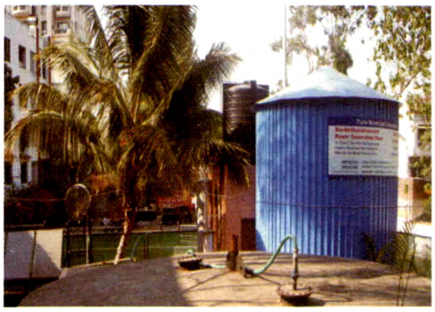
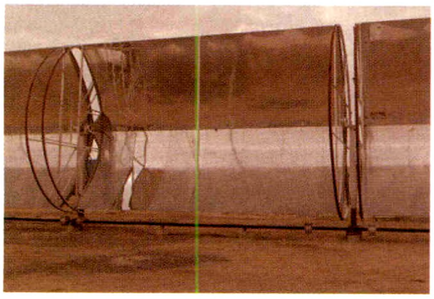
The wind energy sector holds an enormous potential to capture the energy market in India.

Small hydro power does not require the construction of large dams and is free from problems of rehabilitation or deforestation.



Pune Municipal Corporation has taken a remarkable step in developing a municipal solid waste biomethanation plant.

Spain Visit by High Level Indian Delegation



An Indian delegation lead by Gireesh Pradhan, Secretary, Ministry of New and Renewable Energy, visited Spain to observe the solar thermal power plants. The delegation met with Protermosolar, a leader in the concentrated solar power (CSP) industry on 18 April. Pradhan impressed with the solar thermal plants, declared in his speech India's strong commitment towards generating solar energy (both photovoltaic and solar thermal energy). Regarding the ongoing Solar Mission programme of India, Pradhan stated that he was convinced that the first set of 500 MW CSP plants will be a success. Luis Crespo, General Secretary, Protermosolar and President of European Solar Thermal Electricity Association (ESTELA), expressed confidence about the commitment of Indian companies promoting these projects.

Protermosolar and ESTELA have agreed to assist India in terms of both technology development and plant deployment and have offered to provide a well-rounded system that will give all necessary information and advice to the Indian Government. India has embarked on a programme of generating 10,000 MW of solar power. Of this, 3000 MW will be supported by a mechanism that assures guaranteed off take at a fixed price for 15-25 years. The balance 7000 MW will be funded by tradeable renewable energy certificates (RECs) that distribution companies will be obliged to buy from solar power producers.

www.evwind.es, 20 April 2012

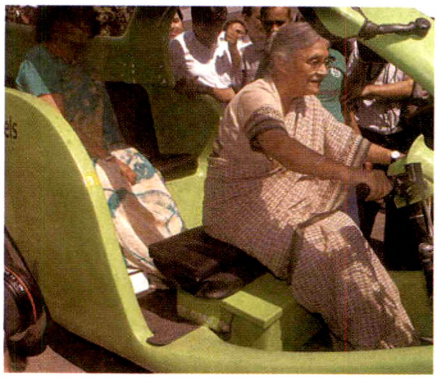
Gujarat Planning Rooftop Solar Power Policy for Households

The State of Gujarat is considering a 'rooftop' solar power plant policy to enable its people to produce their own electricity and earn money by selling surplus power and feeding it into the grid, as declared by Narendra Modi, Gujarat's chief minister, on 19 April.

Gandhinagar, being developed as India's first model solar city, already has solar rooftop systems with capacities ranging from 1 kW to 150 kW at more than 150 locations, aggregating to a capacity of 1.39 MW. These cover a total of two acres of roof-top area, providing 1 per cent of the total energy consumption in the State capital. Recently, the state government floated a 5 MW solar rooftop systems programme on PPP (purchasing power parity) model in the capital. This is now being extended to five more cities and towns. Modi added that the said technology has reduced the cost of solar power production from Rs 15 to Rs 8.5 per unit in the last few years, making it affordable and at par with gas-based power. An ambitious 605 MW solar power project spread across 10 districts is now underway and Modi said that the policy would make the people self-reliant in power generation. This would help them rent out their roofs for installation of such plants thereby helping them earn an extra income and improve their living standards. The solar project has created an additional 30,000 jobs in the State.

www.thehindubusinessline.com, 19 April 2012

Now Green Feeder Vehicles for Metro



In an eco-friendly initiative, a fleet of battery-powered, pollution-free vehicles were inducted into Delhi's transport on April 27, 2012 to provide commuters with feeder services from metro stations. The service, modelled on the lines of similar services in Tokyo, New York and Berlin, was launched by chief minister, Shiela Dikshit.

To start with, the first cluster will comprise 25 such vehicles and will operate between the Malviya Nagar metro station and the Select City Walk mall at Saket in South Delhi. The promoter of the project, Green Wheels Pvt. Ltd., a subsidiary of the Argentum Group, said that they plan to introduce a total of 5,000 such vehicles, branded as G-Rik, within the next 15 months and negotiations are underway with various government agencies.

Ajay Singh, Chairman, Argentum Group said that the new service is aimed at bridging the last mile connectivity to major vantage points in the city. These eco-friendly electric vehicles will usher in a world class mode of travel, and provide for a more efficient, faster and better quality public transport system. The vehicles will be directly managed and operated by Green Wheels. To ensure a hassle-free ride for commuters, the company has put in place a ticketing system with a fixed fee of Rs 10 per passenger per ride.

www.thehindu.com, 28 April 2012

200 MW PV Charanka Park Inaugurated; 600 MW Commissioned

At the inauguration of the Charanka Solar Park in India, photovoltaic projects nearly worth 605 MW were handed commissioning certificates by Gujarat chief minister, Narendra Modi under the Gujarat Solar Policy. These projects have been completed, but have not been grid connected, due to the lack of transmission infrastructure in the State. The Gujarat Solar Park, set up with an investment of nearly Rs 9,000 crore on a 2,669 acre plot of wasteland in village Charanka in Patan district, is the largest part of the State's power project with 200 MW of operational capacity. The overall capacity of the Solar Park, when it expands to 5,000 acres, would be 500 MW by 2014, making it the largest solar farm in Asia. The entire solar power project would produce 30 lakh units of clean energy daily, capable of electrifying 10 lakh households, and save 10 lakh tonnes equivalent of carbon dioxide emissions annually.

Further, at the ceremony, Naoki Sakai, senior energy specialist from the Asian Development Bank (ADB) announced that US $500 m would be made available to the State for solar development. Peter Haas, U.S. Council General, from the U.S. Consulate at Mumbai committed a further $ 500 m dollars to be used for solar and clean energy development in India.

www.pv-magazine.com, 19 April 2012

J&K to have First Wind Power Project at Reasi

Jammu and Kashmir is set to have its first wind power project in the State and a site in the mountainous Reasi district has been found suitable. Officials of the Jammu and Kashmir Energy Development Agency (JAKEDA) reported that the proposed project will come up at a site called Bidda in Reasi district that has high wind potential. To study the wind potential and feasibility of such projects in the State, two wind masts were installed at Ijara in Baramulla district and at Bidda. As per the tests, there is wind potential of about 336 W/m^2 at 50 m height. A project with a capacity of around 10 MW is being envisaged in the first stage. In order to ensure development of the Bidda site, a draft MoU has been prepared and forwarded to the National Hydro Power Corporation (NHPC). Officials at the JAKEDA added that the major criterion for developing a wind farm is to first assess the wind potential. Wind power projects will be taken up when it is approved by the Centre for Wind Energy Technology (C-WET).

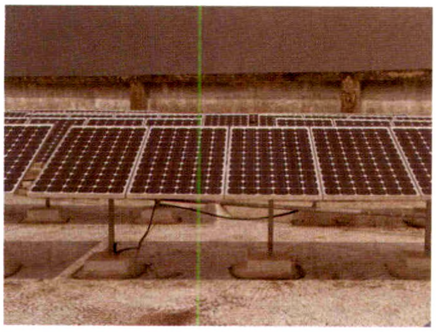
ibnlive.in.com, 19 April 2012

Chennai Readies to Give Country its Solar Atlas

Chennai is getting ready to give India its own solar atlas, which will have details on levels of solar energy radiation in various cities in the country. A team of experts set up by the Ministry of New and Renewable Energy, is working on updating the data of solar energy radiation received from 50 existing automatic solar radiation monitoring centres, of which seven are in Tamil Nadu, and the rest are spread across the country from Ladakh in Kashmir to Chitradurga in Karnataka. There are plans to set up another 60 data centres for this project. The Director of the Solar Radiation Assessment Cell in Chennai, G. Giridhar, stated that the data in the atlas will prove useful for the government and commercial investors, who can learn of potential solar zones in India and invest wisely in specific projects to tap the energy. The ministry is also working on the proposal to make this data available, at a price, to corporates looking to invest in renewable energy as a business and

wanting to set up solar farms in India. This Solar Census Project is the first of its kind in the world to use solar spots to assess potential energy zones.
www.deccanchronicle.com, 20 April 2012

Solar Power All Set to Light Up Border Areas



Border areas of Punjab are all set to go solar as the Punjab Energy Development Authority (PEDA) is planning to install a large number of solar-powered streetlights and water heating systems in public buildings in the Gurdaspur, Amritsar, Tarn Taran and Ferozepur districts. While 90 per cent of the cost of installing these systems in public buildings, including colleges, schools, hospitals and gurudwaras, would be borne by the PEDA, the remaining 10 per cent would be taken care of by local bodies like panchayats and nagar panchayats.

The PEDA has plans to install close to one lakh biogas units in rural areas by the year (2012-13). The Authority has been providing a subsidy of 30 per cent to those switching over to biogas plants. As many as 48,904 of such units have already been set up. PEDA has installed solar powered systems at the Parliament House and has been asked to install an 85 kV solar plant at the Rashtrapati Bhawan, at a cost of Rs 3 crore. Plans are on to set up a similar system at the Punjab Governor's house in Chandigarh, as well.
www.tribuneindia.com, 27 April 2012

West Bengal to Launch New Renewable Energy Policy

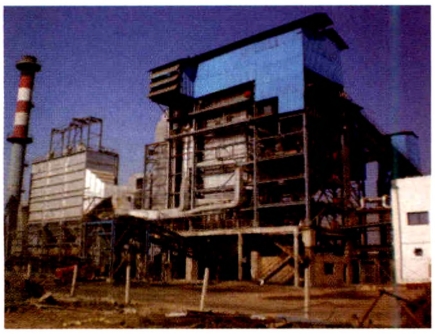
In a bid to encourage efforts to harness the potential of renewable energy sources, the government of West Bengal is planning to introduce a new renewable energy policy. As stated by MK De, Principal Secretary, Department of Power and Non-Conventional Energy Sources, the policy, the draft of which has already been prepared and is awaiting approval, will be based on cogeneration and generation of electricity by using renewable energy sources. The proposed policy intends to encourage investment in renewable energy sources, like wind energy, solar energy, biomass etc, by way of granting various concessions to willing investors. At present, renewable energy accounts for 2.5 per cent of the total consumption in West Bengal. De pointed out that grid-connected large solar plants following the guidelines of the Jawaharlal Nehru National Solar Mission (JNNSM), were not the only normative directive for generation of solar energy, and that the State intends to enhance solar power generation through rooftop installations. In line with this, the State Regulatory Commission has already started focussing on installation of domestic rooftop solar plants.
www.power-eng.com, 26 May 2012

Government Allots Rs 270 crore for Solar-Powered Rickshaws

In an effort to 'go green' , the Samajwadi Party (SP) government of Uttar Pradesh, in its upcoming budget, intends to create an initial provision of Rs. 270 crores, devoted to solar powered rickshaws. Announcing this, the State Minister of Urban Development, Azam Khan said that the government was in talks with several companies like Scooter India, Hero and Bajaj to manufacture the rickshaws. The State has an estimated 1.75 lakh rickshaw pullers and envisages to provide a solar-powered, motorised rickshaw free of cost to each. All rickshaws registered before 15 March 2012, when the SP government was formed, will be replaced in phases. Since each rickshaw is expected to cost around Rs 1 lakh, the scheme will involve an expenditure of Rs 1,750 crore. The rickshaws will be fitted with a motor that runs on a battery which can be charged either through solar power or at battery charging centres that will be set up at various places in the city.
www.indianexpress.com, 26 May 2012

Haryana to Invest Rs 230 crore in Five Biomass Power Projects

The Haryana government plans to set up five biomass power projects at a cost of Rs. 230 crore, to generate



about 51 MW of power. A spokesman of Department of Renewable Energy (HAREDA) stated that two of these projects were near completion, adding that the State's four micro-hydro power projects have also started power generation. These include a 6 MW power project in Dadupur, Yamuna Nagar, a 2 MW project in Gogripur, Karnal, a 1.4 MW project at Musapur, Karnal and another project of 1.4 MW at Khukhni Karnal, costing Rs 58 crore, Rs 22 crore and Rs 16 crore, respectively. He also said that a total of 164 MW of power is being generated in the State through renewable energy sources and 93.9 MW power generation has been added currently. Furthermore, to create awareness about renewable energy devices and energy conservation, HAREDA has set up 21 energy parks at the district level incurring a cost of Rs 1.80 crore.
www.eai.in, 22 May 2012

Thirteen Additional Biofuel Information Centres Soon

According to the Chairman of the Karnataka State Biofuel Development Board (KSBDB), Y. B. Ramakrishna, Biofuel Information Centres will be set in all the districts of Karnataka in the next three months. Speaking at the University of Agricultural Sciences (UAS), Bangalore, Ramakrishna said that 13 more centres will be added to the existing 17. Besides providing information on biofuels, these centres will be equipped to collect different types of non-edible oil seeds, extract oil with a seed crushing capacity of 500-600 kg per day and produce 100 to 150 litres of biodiesel per day. The biodiesel produced will be blended with petrol and diesel and used in several vehicles belonging to the Board and the University and the de-oiled cake will be used/sold as organic manure. At present, Karnataka has the capacity to produce 135 million litres of ethanol from molasses, which will be increased to 200 million litres by this year end. He added that Karnataka is the first State in the country to formulate a biofuel policy, create a task force and constitute a board for the promotion of biofuel.

On the occasion, Chief Minister D. V. Sadananda Gowda inaugurated a national workshop on Rural Agriculture Work Experience (RAWE) Programme and launched the biofuel park website. The workshop was jointly organised by the University of Agricultural Research (UAS), Bangalore, and the Indian Council of Agricultural Research and Biofuel Development Board. Informing about the RAWE programme, Vice-Chancellor of University of Agricultural Sciences, Dr. K. Narayana Gowda explained that under the programme, the students are given rigorous orientation on various issues and problems, which will help provide them with real time opportunities to work on complete crop season through various extension methods.
www.newzstreet.tv/ns, 20 May 2012

Solar Mission Completes 89 per cent of Capacity Goal

The National Solar Mission whose goal is to install 20,000 MW capacity of solar energy by 2020, has commissioned 89 per cent of its allotted capacity in its first stage, informed government officials. The government had signed power purchase agreements (PPA) with 28 solar power developers for 140 MW solar photo voltaic (PV) projects in January 2011, out of which 125 MW of capacity stands commissioned currently. The progress is commendable as most of the projects are commissioned and delayed projects given one month extension with a part of their bank guarantee encashed, informed Tarun Kapoor, Joint Secretary, Ministry of New and Renewable Energy. For the solar thermal sector, PPAs have been signed for 27 projects for a capacity of 470 MW to be included in the first batch. They would be commissioned by May 2013. The NTPC- Vidyut Vyapar Nigam (NVVN) which executes the bidding and trades power with the developers, is satisfied with the result. However, the concerned party would be stricter than before with the mission guidelines and will work more closely with the developers of the second batch informed a senior official of NVVN.
www.epaper.timesofindia.com, 30 April 2012

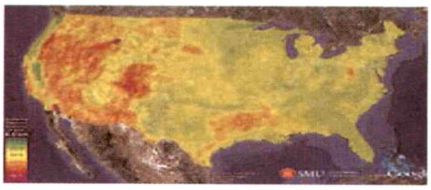
Global Wind Power Capacity to Reach 500 GW by 2016

The global wind industry will install more than 46 GW of new wind energy capacity in 2012, according to a five-year industry forecast published today by the Global Wind Energy Council (GWEC) at the European Wind Energy Association (EWEA) 2012 Conference at Bella Centre in Copenhagen. By the end of 2016, total global wind power capacity will be just under 500 GW, with an annual market in that year of about 60 GW.

Overall, the average annual market growth rate of GWEC projects is estimated at about 8 per cent for the next five years, but with a strong 2012 and a substantial dip in 2013 the total installations for the 2012-2016 period are expected to reach 255 GW, with cumulative market growth averaging just under 16 per cent. Steve Sawyer, GWEC Secretary General informed that for the next five years, annual market growth will be driven primarily by India and Brazil, with significant contributions from new markets in Latin America, Africa and Asia. Asia will continue to be the world's largest market with far more new installations than any other region, installing 118 GW between now and 2016, and surpassing Europe as the world leader in cumulative installed capacity sometime during 2013, ending the period with about 200 GW in total.

www.evwind.es, 19 April 2012

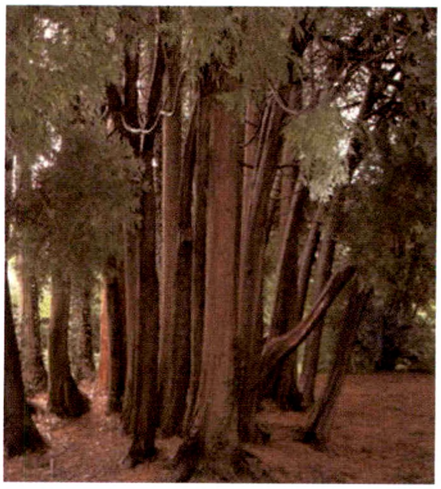
GEA International Showcase to Bring Over 200 Global Leaders to Washington



In May 2012, the Geothermal Energy Association (GEA) hosted its fourth annual International Geothermal Energy Showcase. The showcase featured minister-level speakers from leading geothermal countries, and was held at the Ronald Reagan Building and International Trade Center in Washington, D. C. The event saw key government and industry leaders make decisions about building thousands of new MW of geothermal power, informed Karl Gawell, GEA Executive Director. The GEA saw this as an opportunity to explore and learn about the best policies and approaches to expand geothermal power domestically and abroad. The GEA also announced that POWER Engineers, a global consulting engineering firm's division Galena Advisors, would serve as gold level sponsors for the event. The programme highlighted geothermal projects, policies and development from the world's key geothermal markets. Geothermal power presently supplies the world with 10,715 MW of electricity in 24 countries, but the potential to use geothermal resources is much greater. In a 2010 International Market Update, the GEA had identified 70 countries with new projects under development or consideration.

www.renewableenergyworld.com 19 April 2012

Hawaiian Utility Turns to Biomass as Clean Power Source



Hawaii Electric Light Company (HELCO) has entered into a 20-year agreement to purchase 21.5 MW of biomass power on Hawaii Island from Hu Honua Bioenergy, a deal requiring approval from the state Public Utilities Commission. Hu Honua Bioenergy is converting a former sugar mill into an electric generation plant using biofuel including locally grown biomass, such as eucalyptus. The facility will consist of a biomass fuel yard, steam boiler, turbine and generator. The previous plant used sugar cane waste and later, coal. Estimates are that Hu Honua will be able to supply about 10 per cent of the island's electricity needs. The plant is anticipated to be completed approximately 18 months after refurbishment begins.

Hu Honua's facility will supply us firm renewable energy at prices that are stable and not tied to the unpredictable world oil market and that is good for the customers, informed HELCO President Jay Ignacio. He also added that with the addition of Hu Honua to the HELCO power grid, over 50 per cent of the island's electricity will be provided by renewable resources. Hu Honua estimates that its plant will replace about 250,000 barrels of oil per year. It will employ 28 to 30 persons once in commercial operation.

Hawaii has a clean energy target of 70 per cent renewable energy use by 2030. It is more dependent on crude oil imports than any other state.

www.rechargenews.com,
22 May 2012

California Expands Solar Thermal Incentives for Low-Income Housing

California is leading the way for solar hot water with a new solar thermal incentive, this time for low-income single-family properties and multi-family dwellings. California's original CSI (California Solar Initiative) Thermal rebate programme was introduced in 2010 and is perhaps the most generous solar water heating rebate programme in the United States, offering up to $500,000 for commercial properties and up to $1,875 for individual homeowners. Now, California's Public Utility Commission (PUC) has introduced another incentive that targets low-income housing and individuals named 'The CSI-Thermal Low-Income Programme'. In terms of numbers, the low-income programme provides customers of Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric (SDG&E), and Southern California Gas Company (SoCalGas) with up to $3,750 in rebates - double the regular rebate. For multi-family dwellings, such as apartment buildings, nursing homes, and assisted living homes, owners can receive up to $500,000. The top figure differs from the regular programme in that owners will receive a 50 per cent higher rebate for the natural gas displaced by the solar power system. As the programme grows and more installations come up, the rebate amount will decrease for both programmes, and so will the price of installing solar water heating systems.

solarmakescents.net
18 April 2012

German Solar Power Output Sets World Record

German solar energy production reached a world record of more than 20 GW of output, according to the Institute of the Renewable Energy Industry in Germany. The World of Renewable Energy Industry (IWR) in a press release reported that solar power stations in Germany, at peak times produced as much as 22,000 MW of power. Last year, in reaction to the Fukushima disaster, the German government decided to phase out nuclear power over the course of 11 years while shutting down the seven oldest nuclear plants immediately. A federal study showed that renewable energies could provide more than 30 per cent of the electricity needs in Germany, practically substituting all of nuclear power. A 2000 law guaranteeing fixed rates to producers has resulted in a quick growth of renewable energy in Germany over the last decade.

www.theepochtimes.com,
29 May 2012

Solar Powered Boats Being Made in Rome

A small company called Tamarack Lake Electric Boat Company in Rome, is marketing the first recreational solar powered boat named 'Loon' that is soaking up rays and replenishing energy. Monte Gisborne, the owner of Tamarack Lake Electric Boat Company remarked that it would make perfect sense as the suitable time to go boating is sunny days which would also mean that there is a great opportunity to go solar which is what this boat is all about. Gisborne says he plans to start manufacturing the solar boats for market within the month. According to him, it is a culmination of world politics, and a change in the perception of solar power, high gas prices and environmental awareness, all of which play a part in making it a good time for launching this product coupled with the fact that boaters are beginning to look for something different. Even without a gas engine the 'Loon' can reach speeds rivaling a typical pontoon boat. Presently about 1000 W is generated, which is roughly a quarter of the total power available for the motor. The energy used is constantly being replaced by the sun and the four solar panels on the roof produce energy at a rate of up to more than 700 W, guaranteeing miles of quiet, environment friendly boating.

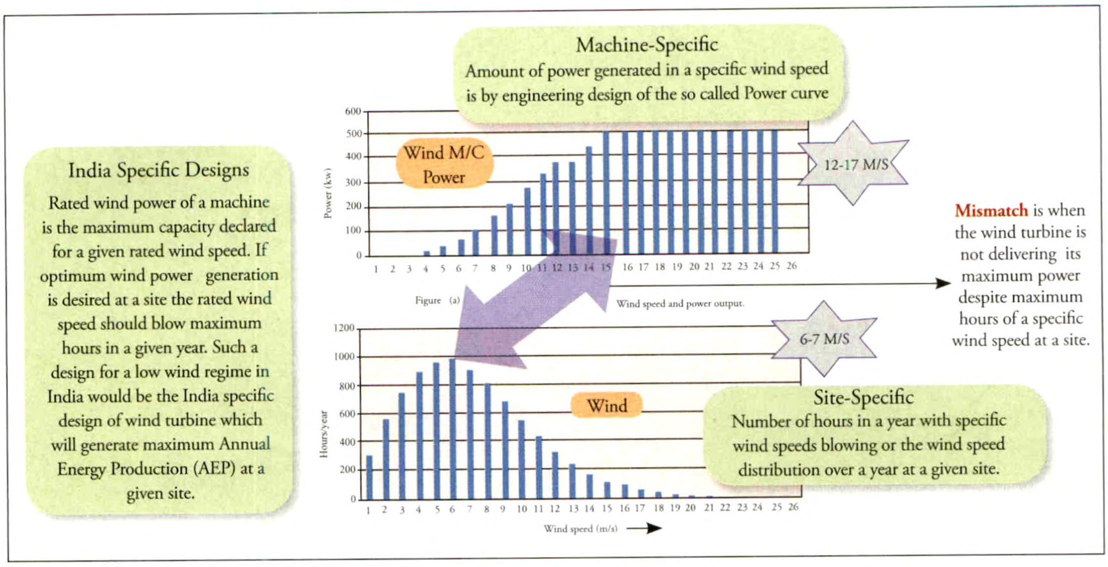
www.renewableenergyworld.com,
3 May 2012

WAY FORWARD FOR INDIA'S WIND POWER BY 2020

India ranks 5th in installed capacity of 17.53 GW, but has higher generation mix of wind generated electricity penetration than USA and China. India's wind power potential is higher at higher hub heights and the REC, CDM route with IPPs would keep the wind blowing, if there is sustained political and societal will.

Dr S Gomathinayagam

Fig 1. The mismatch of machine and site specific wind speeds



India Specific Designs

Rated wind power of a machine is the maximum capacity declared for a given rated wind speed. If optimum wind power generation is desired at a site the rated wind speed should blow maximum hours in a given year. Such a design for a low wind regime in India would be the India specific design of wind turbine which will generate maximum Annual Energy Production (AEP) at a given site.

Machine-Specific

Amount of power generated in a specific wind speed is by engineering design of the so called Power curve

Mismatch is when the wind turbine is not delivering its maximum power despite maximum hours of a specific wind speed at a site.

Site-Specific

Number of hours in a year with specific wind speeds blowing or the wind speed distribution over a year at a given site.

India today, ranks fifth in total wind power installed capacity in the world with over 17.5 GW (MNRE, May 2012) , while China and USA stand at 1st and 2nd positions, with levels above 65 GW and 49 GW respectively (REN 21, 2012) . Though the gap is rather large and even though per capita consumption of electricity in India is much lower than the leaders, India's wind-electricity mix in the total generation of electricity is 3 to 4 per cent (Berkley Lab, 2010) which is actually way ahead of China with 2 per cent and USA with a little over 2.5 per cent. This, in addition to the overall renewable energy mix of 12 per cent with around 25 GW from all renewable sources (nearly 17.5 GW i.e. 70 per cent being wind) out of the net generation capacity of about 206 GW (CEA, 2012), is no mean achievement for a country with a population of a billion, in a democratic multi-party and a multi-cultural, socio-economic and geo-political system.

The wind power generation capacity in India, as per the official estimates by the Centre for Wind Energy Technology (C-WET) long term wind resource measurement programme, is 49.13 GW. It is pertinent to note that the declared potential is based on measured wind data, at different locations in India, at various heights, ranging from 20 m to 50 m masts. This was further substantiated by a detailed international collaborative project, while developing an Indian wind atlas, using a Mesoscale Model developed for India by Risø, Denmark which was validated by the C-WET using the available measured data in India. The potential of 49 GW is calculated with respect to 2 per cent land availability at windy locations and pertains to a 50 m hub height level of the wind turbines.

Presently due to technological advancements, large wind turbines with higher hub heights in the range of 80-100 m with larger rotor diameters upto 102 m are available in the Indian market. The Indian Wind Atlas released in April 2010, notes that when wind speed is increased along the height; and, the potential of 49 GW at 50 m level, is extrapolated to 80 m standard hub height; the projected wind potential using the same 2 per cent land availability will be in the order of 102 GW. With greater per cent of land availability, 'grid evacuation and logistical road infrastructural developments' and possible exploitation of offshore wind potential there is all likelihood for additional alternative possibilities.

This higher potential (102 GW) existing in India has not been officially declared owing to the lack of validation of the mesoscale (otherwise known as a variant of numerical weather prediction - NWP) models with actual mast based measurements at 80 m level. In addition, the earlier declaration of wind potential in India had not systematically considered land use, land cover pattern and actual land

> **Even though per capita consumption of electricity in India is much lower than China and USA, India's wind electricity mix in total generation of electricity is 3 to 4 per cent which is ahead of them.**

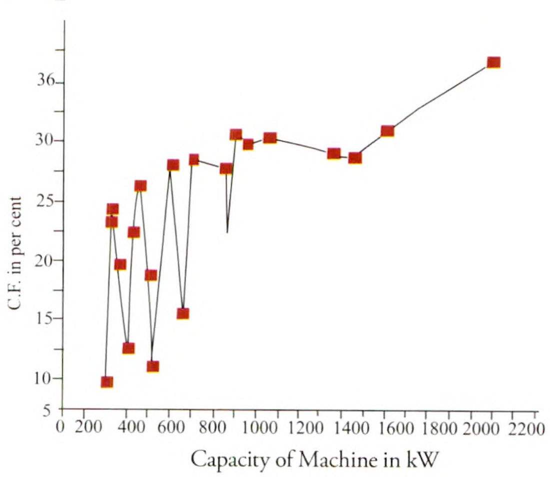
812 MW wind power project installed at Dhule, Maharashtra

availability considering water bodies, agricultural land, forest coverage and other environmentally protected areas. To scale up and give a realistic potential, the government of India, particularly the Ministry of New and Renewable Energy (MNRE) has initiated a project to conduct a realistic assessment considering tangible land availability for wind farming using Geographic Information Systems (GIS) in seven wind potential states - Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan at a 100 m level facilitating the validation of mesoscale based results indicated in the Wind Atlas.

The MNRE in the twelfth five year plan (2012-2017) has envisaged a growth capacity addition of 30,000 MW of renewable energy power with as much as 15,000 MW by wind alone. This should push the net installed capacity of wind to 32,000 MW. The growth in wind energy sector has been all time high in the last financial year to somewhere around 2430 MW which has reached to over 3196 MW by the end of this financial year. The trend is obvious when one looks at the statistics of the Clean Development Mechanism

> **The MNRE in the twelfth five year plan (2012-2017) has envisaged a growth capacity addition of 30,000 MW of renewable energy power with as much as 15,000 MW by wind alone.**

Fig 2. Variation of Capacity Factors with size of wind turbine generators in India



(CDM) projects - where wind forms a major slice of the total renewable energy based CDM projects - 72 per cent. With 21 per cent of all of the world's CDM projects in its kitty, India ranks second in the world.

The current policies of the government viz. accelerated depreciation, generation based incentives, customs/excise duties exemption and years of tax holidays and preferential tariff rates for wind generation are likely to sustain the growth of the wind sector. Even though the accelerated depreciation benefits have been reduced to 15 per cent since April 2012, first year in 12th Five Year Plan, the Independent Power Producer (IPP) mode of execution and the number of CDM projects in wind and the associated Foreign Direct Investments (FDI) through IPPs are likely to boost the growth of wind sector further.

Another major government initiative is the removal of the wind power density (WPD) cap of 200 W/sq.m which was prescribed to ensure viability and techno economic feasibility of the wind power projects with the then available wind turbine generators (WTGs). Since April 2011, to set up wind power projects in areas having low or moderate wind power potential, with modern technology enabled wind turbines of higher hub heights in the range of 80-120 m, the cap of 200 W per sq.m WPD has been removed by the MNRE. This is likely to augment the growth of wind power in newer sites and newer states in India. Fig. 1 is self explanatory on what is the need of the hour for India-specific low wind regime turbines. Fig. 2 gives the growing capacity utilisation factor with larger MW class wind turbines operating in India.

The declaration of the need to have compulsory Renewable Purchase Obligations (RPOs) in various states and its rigorous implementations as an exclusive wind RPO, if enforced, may further increase the rate of growth of the wind energy sector through Renewable Energy Certificates (RECs). Since the REC declaration in March 2011, India has seen a significant increase in the number of RECs with month-on-month growth registered both in terms of price and volumes of RECs traded at the Indian Energy Exchange (IEX) and Power Exchange of India Ltd. (PXIL). The last REC trading session had more than 137 participants and the price per unit was as high as Rs. 3000 per unit -proving that with close monitoring by the Centre and states, the RECs will certainly help in meeting the set targets.

Last but not the least are the focussed deliberations on 'smart grid technologies' and the Renewable Regulatory Fund (RRF) under the National Load Despatch Centre, (NLDC) set up by the Ministry of Power as well as MNRE. The proliferation of renewable energy usage across India and the growing contribution of wind power, necessitates the move towards smart gird technologies to allow greater penetration of this source of energy and to exploit the full potential of wind generated electricity with on-grid/off-grid small wind energy (hybrid-solar) systems (SWES) application of wind turbine generators with net-metering. This will enable several millions to have access to electricity in either the grid connected or the distributed generation mode.

> **Another major government initiative is the removal of the Wind Power Density (WPD) cap of 200 W/sq.m which was prescribed to ensure viability and techno economic feasibility of the wind power projects.**

The SmartGrid Week 2012 meeting (when) concluded in Bengaluru, indicated that India is one of the twelve active contributing members of the International Smart Grid Consortium (ISGC). India has even set up an Indian Smart Grid Task Force (ISGTF) and a forum called the Indian Smart Grid Forum (ISGF), whose activities showcase the growth potential of renewables as a whole and wind energy in particular.

Smart grid technologies are beneficial because with the merger of integrated communication and information technology, an electricity delivery system from the point of generation to the point of consumption including variable rates of billing such as time of day, costing of power is facilitated through the smart grid. With the shift to smart grid, the Ministry of Power is envisaging reliable and cheaper power supply, shifting the peak away from costly power and access to sustainable power for all and the end of load shedding. That wind energy is clean, green and cost competitive is amply clear. If greater stress is laid on net metering, the affluent can switch to roof top wind power with possibly solar as hybrid to pump into the national grid and add to the wind generation which can then reach the needy. ○

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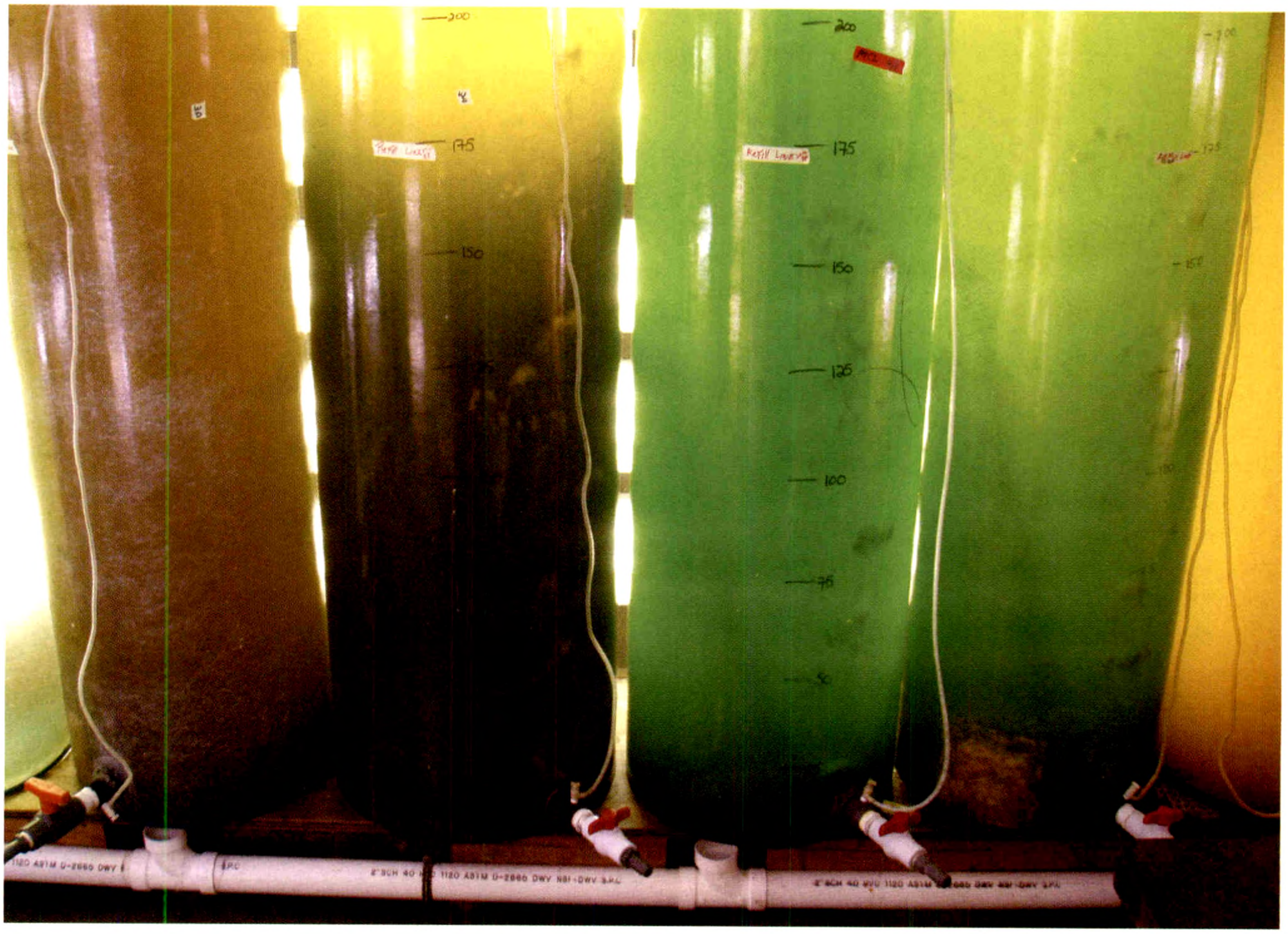
Microalgae

Fuel Source for the Future

Recent research shows that biodiesel from microalgae is one of the most promising renewable biofuel with the potential to completely displace petroleum-derived transport fuel without adversely affecting the supply of food and other crop products - keeping the environment clean at the same time.

U C Banerjee and Priyanka Mishra



The global economy thrives on energy. Currently, India is the sixth largest consumer of energy in the world, and will be the third largest by 2030, with its rising population and consequent consumption of power. At the same time, the country is heavily dependent on fossil sources of energy for most of its demand. Due to the limited crude oil reserves, India meets about 72 per cent of its crude oil and petroleum product requirements through imports, which are expected to expand further in the coming years. The continued use of fossil fuels is not sustainable, as they are finite resources and their combustion will lead to increased energy-related emissions of greenhouse gases. This has necessitated the aggressive pursuing of alternative energy sources - solar, wind, biofuel, small hydro and more. Biodiesel derived from oil crops is also a potential renewable alternative to petroleum. However due to the various issues biodiesel from oil crops and animal fats is not an ideal choice. Moreover it cannot satisfy even a small fraction of the existing demand for transport fuel. Recent research shows that biodiesel from microalgae is the most promising renewable biofuel with the potential to completely displace petroleum-derived transport fuel without adversely affecting the supply of food and other crop products, all this while keeping the environment clean. In fact the oil productivity of many microalgae like Botryococcus braunii and Schiochytrium greatly exceeds the oil productivity of the best oil producing crops.

Microalgae

Algae are the most robust organisms on earth, able to grow in a wide range of conditions and are prominently found in water bodies or damp places. Algae are used as food, as biofilters to remove pollutants from wastewater and as indicators of environmental change. They are also used in space technology and in laboratory research. Commercially, algae are cultivated for cosmetics, pharmaceuticals, nutraceuticals, and for aquaculture purposes. Algae are made up of prokaryotic as well as eukaryotic cells. All algae have plastids to carry out photosynthesis like plants. Chemically, algae contain proteins, carbohydrates, fats and nucleic acids in varying proportions. Depending on their type, the proportion of fatty acids in the overall mass of some algae may be up to 70 per cent. It is this fatty acid (oil) that can be extracted and converted into biodiesel.

Algae can be cultivated by two means i.e. ponds and photobioreactors. Algae capture light energy through photosynthesis and convert inorganic substances into simple sugars using the captured energy. For carrying out photosynthesis, algae need sunlight, CO_2 and water. Open ponds and lakes can be used for cultivation. Algae is the third generation feedstock for biodiesel with higher yield than second generation crops. Its yield is about 50 ton of biodiesel per hectare per year against 2 ton for competing feedstock such as jatropha. Its lipid content is also very high and better than any other crop. Its oil yield per unit area of cultivation can be further increased and a lot of research is currently on going in this field. Making biodiesel from algae oil is similar to the process of making biodiesel from any other oilseed and one can use the same conversion processes to generate biodiesel. Pilot projects forecast that algae can provide more than 10,000 gallons of biodiesel per hectare per year. Recent advances in oil extraction and transesterification could reduce the cost of making biodiesel from plant oils. There may be some challenges in converting algae oil into biodiesel using the transesterification process owing to the high free fatty acid (FFA) of algae oil.

> **Algae can be cultivated by two means i.e. ponds and photobioreactors. Algae capture light energy through photosynthesis and convert inorganic substances into simple sugars.**

Using Photobioreactors

A photobioreactor is a controlled and closed system that enables high productivity of algae. It is a closed system where all the growth requirements of algae cultivation are controlled according to the requirement. The following parameters are generally followed for the growth of algae; temperature 16-27°C, salinity 12-40 g/l, light intensity 1,000-10,000 lux (depending on volume and density), photoperiod (light: dark, hours) 16:8 (min) 24:0 (max) and pH 7-9. Photobioreactors facilitate a much better control of the culture environment such as carbon dioxide supply, water supply, optimal temperature, efficient exposure to light, culture density, pH levels, gas supply rate, mixing regime, etc. The various types of photobioreactors available are tubular reactors (horizontal and vertical), flat panel reactors, vertical column reactors, bubble column reactors, air lift reactors, stirred tank photobioreactors and immobilised bioreactors. Tubular photobioreactors are widely used for the mass cultivation of algae. Cultivation of algae in controlled circumstances gives higher productivity. Photobioreactors greatly improve productivity through their design: the use of clear plastic tubing for efficient and volumetric distribution of light; air lift pumps to keep the algae in suspension; mechanism for gaseous exchange; pH and growth sensors. In photobioreactors, the key systems include: light source, optical transmission system, air handling system, reaction area – the reaction mixing system, gas exchange system (CO_2 injection valve, oxygen release system), nutrient system (feeding tank), filtration system

It is reported that algae yield 30 times more energy per acre than land crops such as soybeans and some estimate even higher yields up to 15000 gallons per acre.

(algae collection filters to remove algal biomass), sensing system (oxygen and CO$_2$ sensors, temperature sensor, pH sensor, light sensor, conductivity sensor), electrical systems and instrumentation systems.

Algae harvesting

Algae are separated from the growing medium and then dried and processed to obtain biofuel. Harvesting methods depend primarily on the type of algae. The most common harvesting processes are flocculation, micro-screening and centrifugation. Selection of easy to harvest strains is important to ensure efficient and relatively inexpensive harvesting. Algal oil can be extracted using mechanical methods (expression/expeller press, ultrasonic-assisted extraction) or chemical methods (hexane solvent method, soxhlet extraction, supercritical fluid extraction).

Biofuel from algae

It is reported that algae yield 30 times more energy per acre than land crops such as soybeans and some estimate even higher yields up to 15000 gallons per acre. It keeps the earth clean and free from pollution as these algal biodiesel fuels help to utilise a resource that is available in abundance just waiting to be harnessed and exploited. Various forms of biofuel from algae are shown in Fig 1.

The procedure for the preparation of methyl esters varies from oil to oil depending upon each one's chemical composition and FFA content, shown in Fig 2.

Fig 1. Showing various forms of biofuels

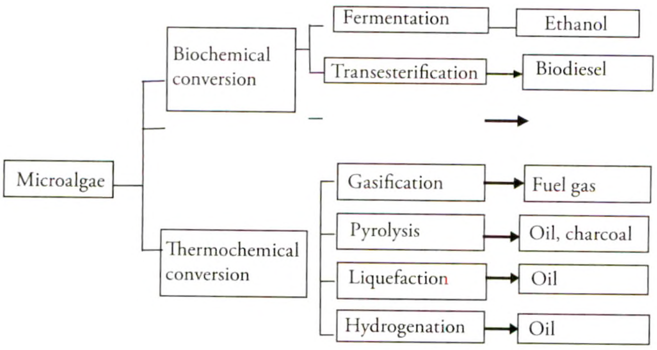
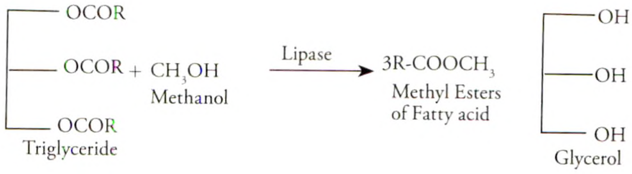


Fig 2. Showing the preparation of methyl esters depending upon their chemical composition and FFA content



The first step is to remove water from oil by increasing its temperature to 120 °C for about 5 to 10 minutes. Then it is allowed to cool and mixed with sodium hydroxide and methanol by stirring - sodium methoxide is produced. Clean oil is heated to 60°C for 5 minutes, mixed with the sodium methoxide and the mixture is transferred to an ultrasonic or mixer equipment for the agitation of the solution for 30 minutes after which it is cooled and separated. Microalgae produce lipids in the form of triacyglycerols (TAGs). Comparatively, algae produce more oil than any other oilseeds which are currently in use. Many microalgal species can be induced to accumulate substantial quantities (more than 60 per cent of their own biomass) of lipids. Microalgae have the highest oil yield among various oil plants. It can produce up to 100,000 lts oil per hectare per year, whereas palm, coconut, castor and sunflower produce up to 5950, 2689, 1413 and 9521 per hectare per year, respectively.

Algae biodiesel characteristics

Algae biodiesel has many positive characteristics making it a fuel that is sustainable and great for use. It has no sulphur content and has superior lubricating properties, reducing the wear and tear of the fuel system - increasing the life of the fuel injection equipment. Algae biodiesel has more aggressive solvent properties than petrodiesel and even dissolves varnish residue. Biodiesel has about 5-8 per cent less energy density than petrodiesel, but with better lubrication and combustion efficiency, its overall fuel efficiency decrease is only about 2 per cent. The cloud point, or temperature at which pure biodiesel (B100) starts to gel, is about 32°F. A blend of B20 (20 per cent biodiesel, 80 per cent 0251t petrodiesel) generally does not gel in cold weather. Various additives will lower the gel point of B100. Biodiesel's flash point is 266°F, significantly higher than petrodiesel's at 147°F, or gasoline's at 52° F. Biodiesel reduces particulate matter by 47 per cent as compared to petrodiesel and reduces the solid carbon fraction on the particulate matter while increasing the amount of oxygen. It has higher yields and hence lower costs. The most significant benefit however is in the yield of algal oil, and hence biodiesel. According to some estimates, the yield of oil from algae is 200 times more than that of the best-performing plant/vegetable oils. Soybean produces less than 50 gallons of oil per acre and rapeseed generates less than 130 gallons per acre while algae can yield up to 10,000 gallons per acre. Algae can grow practically in every place where there is enough sunshine. The biodiesel production from algae also has the beneficial by-product of reducing carbon and NOx (oxides of nitrogen) emissions from power plants, if the algae is grown using exhausts from the power plants. Algae produces a lot of polyunsaturates, which tend to decrease the stability of biodiesel. But polyunsaturates also have much lower melting points than monounsaturates or saturates, thus algal biodiesel would have much better cold weather properties than many other bio-feedstock. Since one of the disadvantages of biodiesel is their relatively poor performance in cold temperatures, it appears that algal biodiesel might score well on this point. Table 1 shows the comparison of biodiesel from microalgae.

> **Microalgae has the highest oil yield among various oil plants. It can produce up to 100,000 lts oil per hectare per year, much higher than palm, coconut, castor and sunflower.**

SWOT analysis

A Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis indicates that higher strength lies in the generation of algae culture on a large scale. The coastal stretch of India is long, measuring 7,500 kms, and is capable of generating massive amounts of algae. According to experts the country can become self-sufficient in liquid fuel if even 2-3 per cent of India's total land is utilised for algae farming and since the opportunity of algal cultivation in the Indian context is very high many research institutes have started work on the same. Besides production, this process is useful in the generation of rural employment for the cultivation, processing and use of the microalgae. Additionally animal feed can also be generated from the waste. However, there are roadblocks in the process. Firstly, microalgae have high water content (80 to 90 per cent); and therefore, not all energy conversion processes of biomass can be applied to microalgae. Secondly, not all algae are capable of producing enough oils, and only those species which are capable of producing more than 50 per cent dry weight of extractable oil, are mainly used. Botryococcus braunii contains an unusually high level of hydrocarbons (upto 80 per cent of the dry mass), making it a great option as a primary biofuel source. Hence the selection of the right kind of algae culture is essential. However, recent developments in biological sciences (recombinant deoxyribonucleic acid (DNA) technology) and the availability of user friendly technology may overcome these problems. Another issue is that first generation biofuels (bioethanol) compete with food production and create the 'food versus fuel' controversy. But second-generation biofuels derived from non-food sources like jatropha, karanj, microalgae, microbial sources, ligno-cellulosic biomass and bio-ethers are much better options for addressing energy security and environmental concerns. Among the second generation biofuels, micro-algal biofuels appear to be the most promising. However, there are hurdles like the absence of Indian microalgal database available to facilitate a selection of the best strains. To solve this problem scientists from across the country, belonging to a consortium of nine laboratories, are working on an ambitious project called the 'New Millennium India Technology Leadership Initiative' (NMITLI), to develop a viable and scalable process of producing biofuel from microalgae, undertaken by the Council of Scientific and Industrial Research (CSIR), New Delhi.

Table 1. Comparison of biodiesel from microalgae with diesel fuel

Properties	Biodiesel from microalgae	Diesel fuel	ASTM* Biodiesel standard
Density (per kg)	0.864	0.838	0.86 - 0.90
Viscosity(mm^{2}per s)	5.2	1.9 - 4.1	3.5 - 5.0
Flash point(°C)	115	75	Min. 100
Solidifying point(°C)	-12	-50 to 10	-
Cloud point(°C)	-11	-3.0 (max- 6.7)	Summer max zero Winter max ≤ 15
Acid value (mg KOH per gm)	0.374	Max 0.5	Max 0.5
Heating value (MJ per kg)	41	40 - 45	-
H/C ratio	1.81	1.81	-

*American Standards Testing Measurements

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Perspectives on Biohydrogen Production

Hydrogen has desirable characteristics and its energy content makes it the fuel of the future. With a fast paced economy and heavy dependence on fossil fuels for meeting energy requirements, a new formula of creating hydrogen using biomass is a technological advancement as well as a challenge.

S Seshadri and V Shashirekha

The energy sector has assumed significant importance in developing countries due to the ever-increasing energy needs of the growing population and India is no exception. Continuous use of fossil fuels is now recognised as unsustainable due to their depleting supplies, contributions to global warming and acid rain, which consequently affects the earth's climate, land, vegetation and aquatic ecosystems.

Hydrogen (H_2) has been tipped as one of the more suitable energy carriers from the technological and environmental perspective of the 21st century, particularly within the context of sustainable development. Hydrogen has several desirable characteristics - it is a colourless, odourless, flammable gas, which is low in density when compared to other gases and disperses rapidly into the atmosphere. It is gaining importance due to its high energy content i.e. 120.7 KJ/g which is the highest energy content per unit mass among known fuels. It is recyclable, non-polluting, yields only water after combustion and has high conversion efficiency. These characteristics make hydrogen the fuel of the future.

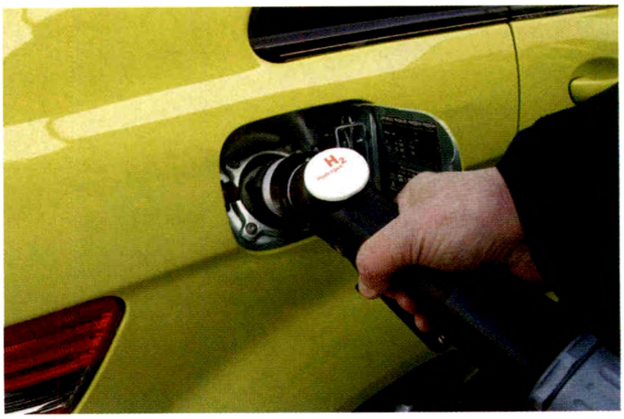
Hydrogen can be used for power generation, heating and also for transport applications. It is possible to use it in internal combustion engines, directly or mixed with diesel and compressed natural gas or directly as a fuel in fuel cells to produce electricity. The advantages are the fact that hydrogen use results in nearly zero emissions and it opens up the possibility of decentralised production on the basis of a variety of fuels. However, despite energy content per unit mass being high - energy content per unit volume of hydrogen is rather low. And the challenges in the storage of hydrogen for civilian applications are greater. There is a common worldwide understanding that hydrogen cannot play a major role without considerable research, technological innovation and cost reduction in its production and storage.

Sources and Methods of Hydrogen Production

Hydrogen can be derived from a variety of energy sources. A variety of process technologies can be used, including chemical, biological, electrolytic, photolytic and thermo-chemical etc. Theoretically, hydrogen can be derived from any hydrocarbons such as oil, coal, petrol, natural gas, methanol and propane as well as biomass and organic wastes. The most common industrial methods for producing hydrogen include steam reformation of natural gas, coal gasification and splitting water with electricity typically generated from fossil fuels. Other methods for producing hydrogen exist but are still being researched which include thermal conversion of water using heat from nuclear or solar thermal power stations; hydrogen production using algae; and, using waste gases from landfills or water treatment plants.

Biohydrogen Production

Among various hydrogen production processes, biohydrogen production technology has the unique possibility of using



A car tank being filled with hydrogen as fuel renewable energy sources like biomass (Table 1). Biohydrogen technologies provide a wide range of approaches including direct and indirect photolysis, photo-fermentation, and dark-fermentation and are known to be less energy intensive, for they can be carried out at ambient temperature and pressure.

Table 1. Modes of biohydrogen production with groups of bacteria

Mode	Aerobic/anaerobic process	Groups of bacteria
Fermentative	Strict anaerobes	*Clostridium Sp., Caldicellulo siruptor saccharolyticus*
	Facultative anaerobes	*Enterobacter aerogenes,* *Escherichia coli,* *Citrobacter Sp*
Photosynthetic	Oxygenic	*Cyanobacteria - Anabaena variabilis, Nostoc punctiforme* Green algae -*Chlamydomonas reinhardtii*
	Anoxygenic	*Rhodobacter sphaeroides* *Rhodospirillum rubrum*

While biological methods mainly include photosynthetic and fermentative hydrogen production, these are associated with the activity of two very common enzymes (hydrogenase and nitrogenase), and the shortlist of candidates targeted for focused study represents fermentative bacteria, photosynthetic microbes such as cyanobacteria, microalgae and purple bacteria. Hydrogen production by direct photolysis occurs in photosynthetic microorganisms like green algae that convert sunlight into useful, stored chemical energy by the following general reaction: $2H_2O/2H_2 \rightarrow O_2$. Indirect photolysis occurs in *Cyanobacteria* that can synthesise and evolve hydrogen through photosynthesis through a two phase process: $12H_2O \rightarrow 6CO_2/C_6H_{12}O_6 \rightarrow 6O_2$ followed by $C_6H_{12}O_6 \rightarrow 12H_2O/12H_2 \rightarrow 6CO_2$. Hydrogen production through photo-fermentation occurs in purple non-sulphur bacteria, catalysed by nitrogenase under nitrogen-deficient conditions using light energy and reduced compounds (organic acids): $C_6H_{12}O_6 \rightarrow 12H_2O/12H_2 \rightarrow 6CO_2$. Hydrogen production by dark-fermentation is carried out by anaerobic bacteria, grown in the dark on carbohydrate-rich substrates (Fig.1). Fermentation reactions can be operated at mesophilic (25 - 40°C), thermophilic (40- 65°C), extreme thermophilic (65- 80°C), or hyperthermophilic (>80°C) temperatures. While direct and indirect photolysis systems produce pure hydrogen, dark-fermentation processes produce a mixed biogas containing primarily hydrogen and carbon dioxide (CO_2), but which may also contain lesser amounts of methane (CH_4), carbon monoxide (CO), and/or hydrogen sulphide (H_2S) that presents technical challenges with respect to the use of hydrogen for various applications. Among these hydrogen production methods, dark fermentation from organic wastes seem to be the most promising and environmentally friendly method as it combines hydrogen generation with waste treatment.

> **H_2 is gaining importance in the context of energy mainly because of its high energy content i.e. 120.7 KJ/g which is the highest energy content per unit mass among known fuels.**

A number of studies have been carried out all over the world to produce biohydrogen from various sources including industrial waste waters. However, most of the systems, though they have achieved hydrogen production using individual cultures/microbial consortia, still look for technological improvisation to make hydrogen yield levels commensurate to the inputs and expenses involved in the process and identification/development of a proper system to utilise the hydrogen efficiently and economically (Table 2).

Challenges and Perspectives in Biohydrogen Production

Biological hydrogen production (BHP) is the most challenging area of biotechnology and it is perceived worldwide as a developmental process that requires extensive biotechnological interventions through considerable research and technological innovations. Technical challenges that face biohydrogen production includes selection of microbes, conversion efficiencies, feed stock types and their availability, identifying the right conditions, molecular understanding, engineering applications and the need to safely integrate hydrogen production systems with hydrogen purification, storage and technologies for efficient utilisation.

While biomass gasification can utilise renewable feed stocks derived from agricultural and/or forestry residues, these processes generate a variety of gaseous, and in some cases liquid residues also as co-products which require attention. The inefficiency in photo biological hydrogen production needs to be addressed to decrease the factor by at least 15 times through optimisation of sunlight conversion efficiency. This calls for developments in systems for improved sunlight collection and transfer and improved photo

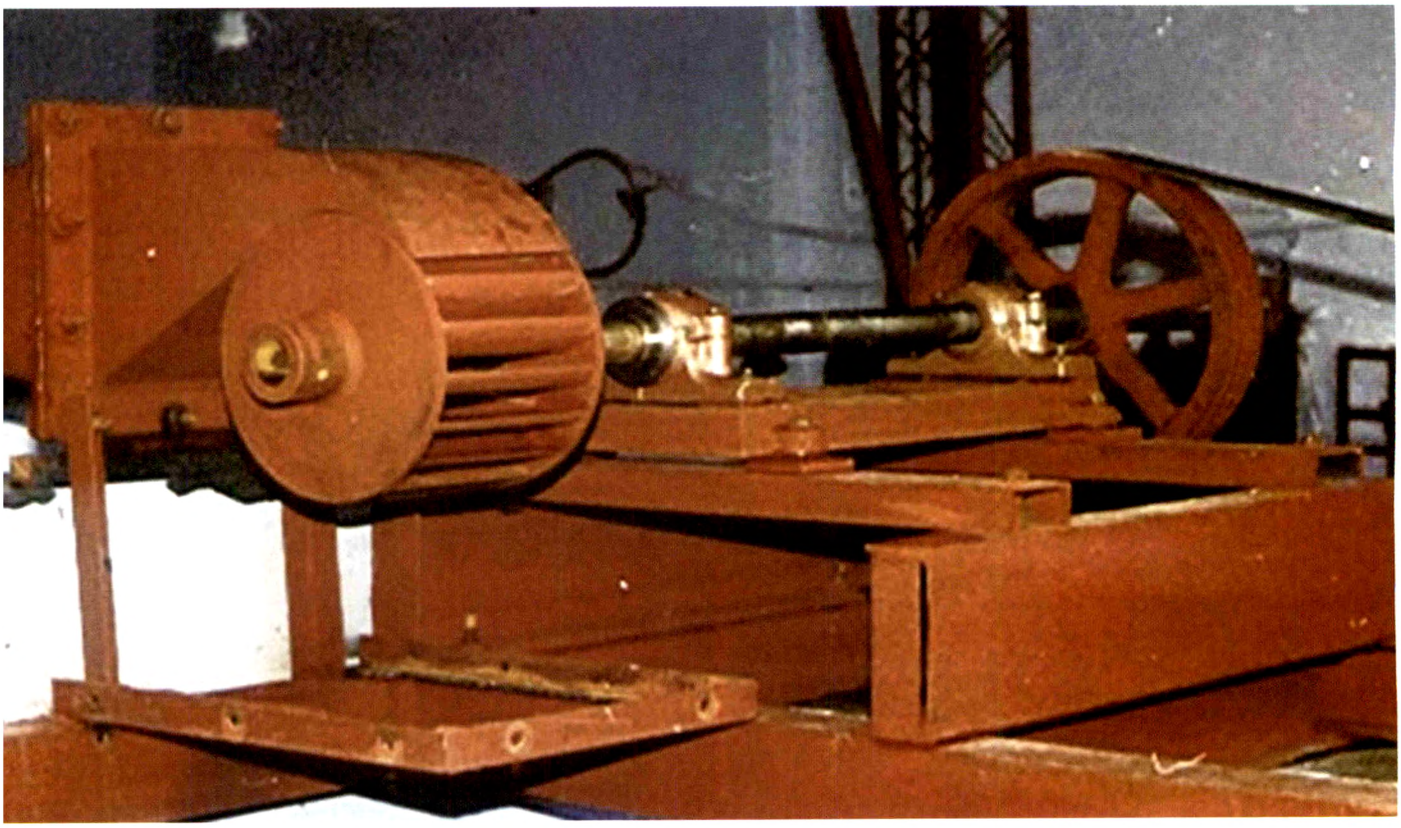


Fig 3. Improved water mill (multipurpose power unit)

Based on the survey of water mill sites, it is found that these micro hydro power sites have capacity upto 5 kW and may be considered an appropriate resource to meet the energy demands of the people.

helped overcome a majority of the constraints discussed above. In the hills, water mills commonly known as 'gharats', have a significant role in utilisation of mechanical power from water streams, mainly, for grinding purposes. These mills operate under head range of 2 to 10 m with an average 1.5 kW mechanical outputs. The efficiency is extremely low and does not provide enough economic incentives to the mill owners. In the Himalayan ranges, from Kashmir to Arunachal Pradesh, thousands of water mills are used for grinding cereals. In hilly, remote areas, mechanical power is required for agro-processes like milling etc. to improve productivity. The demand for electricity for basic lighting, in such areas is becoming a priority. Based on the survey of water mill sites, it is found that these micro hydro power sites have capacity upto 5 kW and may be considered as appropriate resource to meet the energy demands of the people. Though there is a lack of readily available turbines (improved water mills), this has encouraged the development of cost effective designs of standard water mills. In the light of the scope of the upgradation of water mills in the Himalayan and sub Himalayan regions, the development of scientific designs for water mills has been taken up by the AHEC with the financial support of the MNRE and Department of Science and Technology, GOI. The improved water mill (Fig. 3) is capable of grinding 3-4 times more grain than traditional water mills. In addition, a simple machine capable of producing up to 10 kW of mechanical power for driving agro-processing machines directly and for generating electricity if connected with an alternator has also been developed. The turbine is the 'open cross flow' type which has an 'over hung' configuration. The weight of the machine is much lighter and can be easily transported at the site.

Based on these standard designs, local manufacturers have started fabricating water mills and several of them have had the performance of the turbines tested by the AHEC. Thus hydro power is making its presence felt in a small yet powerful way ❂

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Geothermal Energy

Heat has been retained within the earth since the birth of the planet. This heat is exploitable and the essay outlines possibilities of tapping geothermal energy from various locations spread around India.

Rajesh Sharma

Kali valley, northeast Kumaun where a number of hot springs are present

Geothermal energy, distributed globally in geologically specialised zones, has become a reliable and inexhaustible source of energy. Hot springs have been used as a source of earth energy since time immemorial. Electricity was first produced from geothermal steam in 1904 at Larderello, Italy. At present, about 60 countries utilise geothermal energy for societal benefits and about 20 produce electricity from geothermal source systems. High geothermal activity is generally associated with convergent or divergent plate boundaries, which characteristically are locales for the higher geothermal gradient and high heat flow, and because of the high seismic activity, high tectonic movement and enhanced magmatism confined to these tectonic zones - linked geothermal systems are also existent in these areas. In addition, magmatic rocks, active tectonic and the presence of specific minerals like

Springs have been used as a source of earth energy from historical times, and the electricity from it was first produced as geothermal steam in 1904 at Larderello, Italy.

uranium may cause in geothermal springs to occur in an area. All these geological processes lead to subsurface high heat flow. The attributes of this geothermal system are the emergence of springs of hot water and at times, of steam. The physical parameter of geothermal springs can be measured, and the chemical composition of their water can be determined which also helps to calculate the source area temperature. In addition, micro-droplets of trapped fluid have been used for understanding the paleo-temperatures in the geothermal fields. Shallow to deep drilling can be employed to obtain the thermal log, subsurface temperature contouring, geophysical monitoring, heat flow and discharge –recharge information.

There are about 300 hot springs in India distributed from Himalaya to West Coast to the Son-Narmada lineament to Eastern Ghats in Orissa. Although there was an early start for the study of geothermal resources by Schlagintweit, Oldham, Holland, Heim and Gansser in the nineteenth and early twentieth century, yet planned work in the form of the geothermal atlas of India was published by Geological Survey of India (GSI) only in 1991. Subsequently in 2002, the GSI compiled the geothermal energy resources of India in the form of a special publication. Classical comprehensions on the concepts of geothermal resources, their global scenario, exploration techniques and corridors have been presented by Gupta (1980) and Gupta and Roy (2007).

The geothermal provinces of the orogenic belts in India are the Himalayan geothermal province including northeastern syntaxis and the Andaman-Nicobar geothermal province. Among the non-orogenic geothermal provinces of Central and Peninsular India, significant are the Son-Narmada lineament, East and north Indian provinces, West coast, Godavari and Damodar valleys and the Cambay basin geothermal province. The basic work including identification of the area of thermal signatures, geology of the geothermal field, measuring surface temperatures and estimating base temperatures, analysis of hot water etc., have been carried out on many of the Indian hot springs by different organisations and institutions though significant efforts have been made mainly by the GSI. Conventional methods of Na-K-Ca (sodium/potassium/calcium) thermometry and silica thermometry have been largely employed to reveal the base temperatures, and in limited cases, isotopic compositions of water are also determined. Reasonably detailed investigations have been conducted on selected geothermal fields such as Puga, Chhumathang, Manikaran and Sarguja geothermal fields. Herein, geohydrological studies, geophysical surveys, discharge rate, availability of recharging water and water chemistry, tritium concentration have been investigated. In some cases the isotope systematic have been applied to understand the geothermal systems. Drilling has also been employed at selected sites to comprehend subsurface geology, structure, and thermal logging in the boreholes. Major geothermal fields showed abnormally high geothermal gradients. This might be because of the still cooling magmatic bodies and the shear heated rocks.

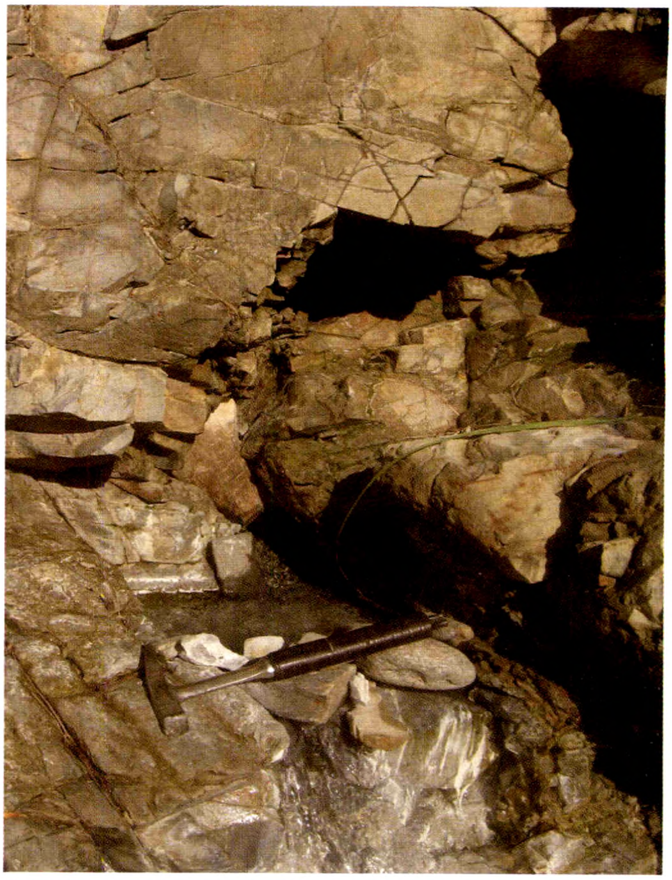
Fig 1. A hot water spring in Kumaun Himalaya.

Distribution of hot water springs in the Himalayas show that a majority of them are located along the main lineaments almost throughout their strike lengths. Although numerous small hot springs are clustered here, about half a dozen significant geothermal fields are recognised, which include Puga and Chhumathang in Ladakh, Tattapani and Manikaran (Beas and Parbati valleys) in Himachal, Tapoban, Bhapkund, Kali valley geothermal fields in Uttarakhand. Also the valleys of major rivers in northwest Himalaya (Fig. 1) consist of many hot water springs particularly near Central Himalaya. A general decrease in the temperatures of hot waters in the springs in the Himalayas from north to south is evident. The oxygen isotope in hot water from the Puga geothermal field suggests the high rock water interaction and one can infer the possibility of subsurface movement of water in high geothermal gradient. The sulphur isotopic values for the sulphur collected from two of the hot springs in Kumaun match with the sulphide minerals found in an adjacent locality.

The current evolving view proposes that meteoric water percolating through the lineaments gets heated at depth and subsequently ascends to the surface in the form of a hot water spring. Such a concept is also supported by the occurrence of hot water spring at or near the river bed in many of the areas. But all the tectonic planes do not consist of appreciable geothermal activity. The clustering of these springs in the region of active tectonics, occurrences of leucogranites near many of the hot springs, and the evidences of trapped metamorphogenic fluids leads to the inference that multifaceted reasons may be involved in the evolution of geothermal systems. The temperature measured at site of the hot springs water varies from about 25°C to extrusion of water- steam mixture at boiling temperature. The base temperatures are also found varying from about 50°C to above 225°C. Although hot water springs in valley fills are common, however, in many cases they are located at the river bed resulting in mixing of river water as soon as the hot water comes to the surface. This causes difficulty in measuring the hot water temperature at the site of emergence. River water may also permeate in the cavity of hot water spring. The mixing of descending meteoric water is yet another diluting phenomenon. Despite all this, geothermal systems deserve attention due to updated studies aiming at their utilisation. The use of geothermal energy largely depends on the temperature, pressure, quality of geothermal fluids and the estimated/ visualised life of the geothermal system.

Among the non orogenic geothermal fields, the Son-Narmada-Tapti-lineament is promising wherein about 35 hot spring have been identified. Although the temperatures of hot water here is generally low (<50°C), but in the prominent geothermal fields at Sarguja in Chhattisgarh the temperature of hot water ranges upto boiling point. A detailed investigation has been carried out on the Tattapani hot springs of Saguja by the GSI and Oil and Natural Gas Corporation (ONGC). Geology and subsurface geology was established, geothermometry-geochemistry of water and gas, and the geophysical surveys were carried out. Borehole data of this geothermal system was used to draw lithologs, thermal logs and temperature contours. Based on these studies, establishment of a power plant was recommended. Further, Khed, Rajwadi, Ganeshpuri and Unabdeo are some significant geothermal systems consisting of a number of geothermal hot springs in Maharashtra. The hot springs in Rajasthan, Gujarat, Andhra, Karnataka, Tamil Nadu and Kerala generally show temperature of thermal water below 50-60°C Their thermal energy can be utilised for industrial purposes and for tourism. However, the geothermal energy from the elevated temperature hot water springs associated with the Cambay graben (Sabarmati rift) is promising.

There are about 300 hot springs in India distributed from the Himalaya to the West Coast to Son-Narmada lineament to the Eastern Ghats in Orissa.

Many of the hot springs are sites for tourism such as Chavalpani hot spring near Pachmarhi in Madhya Pradesh and Tattapani in Himachal Pradesh, and a few others are located at places of religious importance like Badrinath, Manikaran etc. The hot water of some of the springs consists of dissolved sulphur and minerals making it therapeutic and of medicinal value. A few such hot springs are found in Garhwal and Kumaun Himalaya, and many are found in Sikkim wherein the significant ones are at Phurchachu, Yumthang, Borang and Ralang. Overall, the geothermal systems of India are promising and invite attention for greater detailed studies. However skilled manpower and a multi-parametric approach are required. The drilling set for the study and exploration of geothermal resources have been generally shallow and a deeper drilling may be helpful. Studies on paleo-temperatures and variation in temperature over the past years would be useful. The discharge rate of hot water and the availability of water recharging the hot spring are significant for evaluating the continuum in geothermal energy ✪

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BIOCHAR
An Effective Substitute for P-Fertilisers

With energy demands growing at a frenetic pace, alternative sources of energy with their tag of sustainable use are becoming highly sought after to fill the gap between supply and demand. Apart from other renewable sources, energy from biodegradables today has great potential and efficiency to measure up to meet this growing demand.

G P Nagori

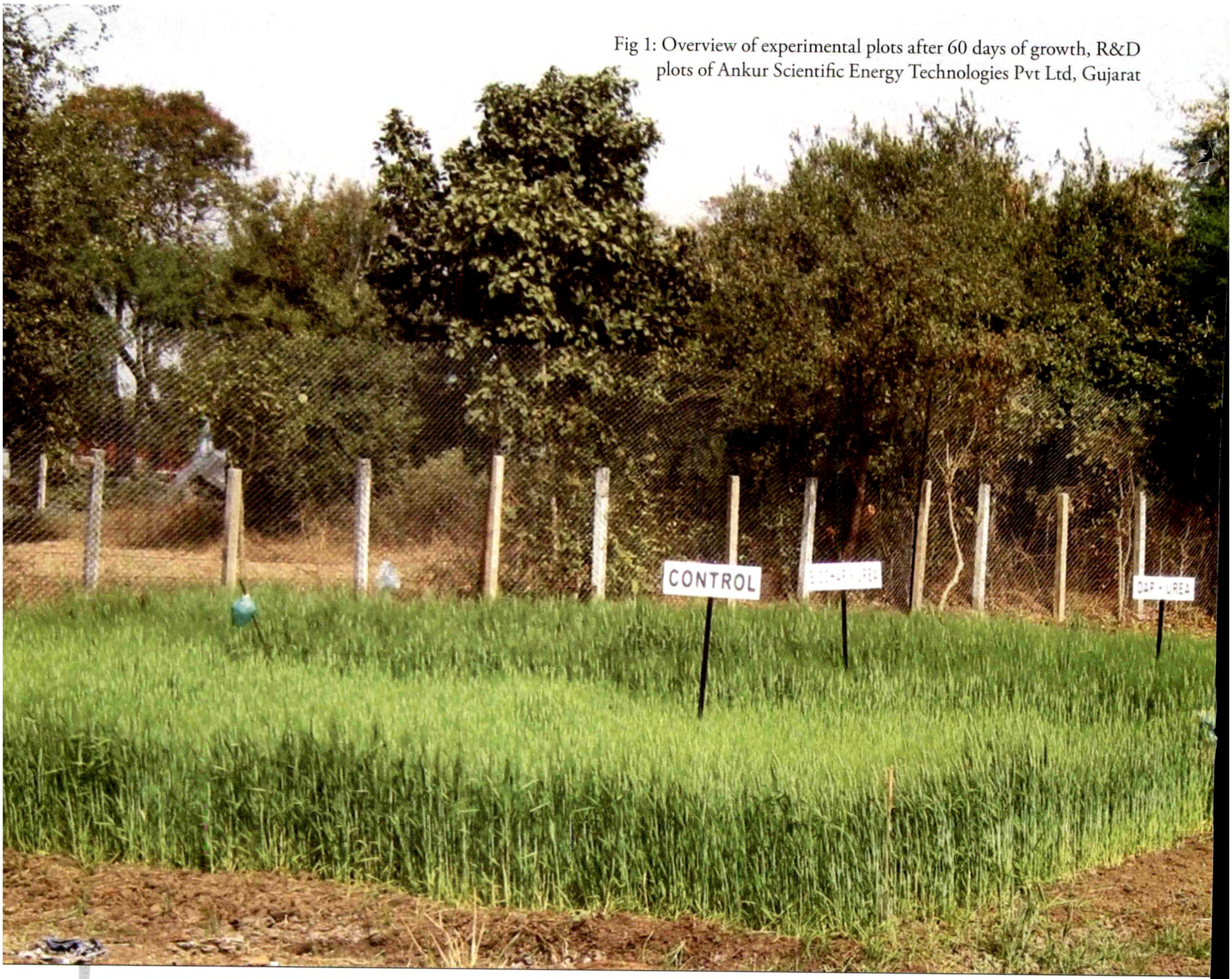
Fig 1: Overview of experimental plots after 60 days of growth, R&D plots of Ankur Scientific Energy Technologies Pvt Ltd, Gujarat

In a country like India where agriculture is the mainstay of the economy and all efforts are being made to ensure a good crop, fertilisers play a major role in ensuring healthy productivity of a crop. However, chemical fertilisers, though they enhance the quality of the crop and protect it from harm, cause long term side effects on the health of the environment, humans and animals. In such a situation, it becomes imperative that science stresses on the development of eco-friendly, sustainable fertilisers and biochar is one such product. It is carbon rich, produced when biomass, such as wood, crop residues or agro-industry wastes, is heated with little or no available oxygen. In technical terms, biochar is produced by the thermal decomposition of organic material under limited supply of oxygen, and at relatively low temperatures. Gasification is one of the dominant thermal decomposition processes producing gas along with biochar. It is the process of converting solid fuels to a gaseous form and involves drying, pyrolysis, combustion with air, reduction of the product of combustion into combustible gases, (carbon monoxide, hydrogen, methane, some higher hydrocarbons) and inerts, (carbon dioxide and nitrogen). At the end of the gasification reactions, about 6-10 per cent biochar is produced as a by- product. Wood char produced from gasifiers has 7-10 per cent ash and 70-75 per cent fixed carbon. Its calorific value ranges from 5500-6500 kcal/kg and it can be used as fuel in boilers or domestic cook stoves.

Biochar is an excellent soil enhancer and can be a harbinger of hope to increase food security and crop land diversity in areas with severely depleted soils, scarce organic resources, and inadequate water and chemical fertiliser supplies. Biochar is highly porous and improves water quality and quantity by increasing soil retention of nutrients and agrochemicals for plant and crop. Nutrients tend to stay within the soil that is treated with biochar, rather than dissolving into groundwater and causing pollution.

Considering the multiple benefits of biochar on plant growth, systematic studies on application of gasifier biochar on crop were carried out at the R&D plots of Ankur Scientific Energy Technologies Pvt Ltd in Gujarat. (Fig 1) Field experiments were carried out using wheat, considering it contributes to about 60 per cent of the daily protein requirement and more calories to the world diet than any other food crop. As a main staple food, wheat continues to assume greater significance in years to come.

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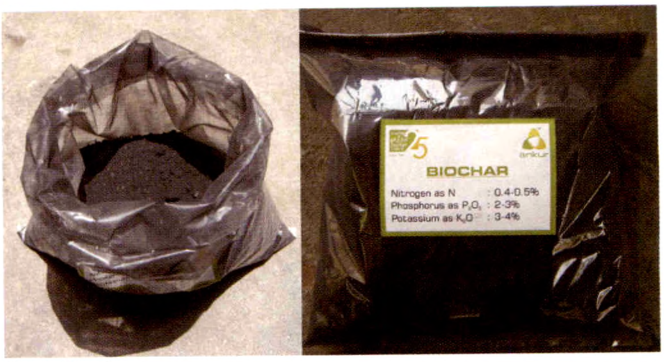

Fig 2: Biochar

Table 1. Physio-chemical and nutritional properties of biochar

Parameter	Values
Moisture, per cent	4.72
Ash, per cent of dry wt	19.26
Volatile, per cent of dry wt	3.68
Fixed carbon, per cent of dry wt	77.06
Calorific value, kcal/kg dry wt	6609
Nitrogen as N, per cent of dry wt	0.46
Phosphorus as P_2O_5, per cent of dry wt	2.70
Potassium as K_2O, per cent of dry wt	3.90

Biochar Characteristics

Biochar produced from the gasifier was analysed for its physio-chemical and nutritional properties. Fig 2 shows the product - biochar. The results of analysis are given in Table 1. Biochar is rich in carbon and has higher values of P_2O_5 and K_2O when compared to farmyard manure (FYM).

Experimental Site, Soil and its Characteristics

The experimental site is located at an altitude of 35.5

Table 2: Chemical Properties of the Soil in Experimental Site

Parameter	Values
Soil pH (1:2 soil: water suspension)	7.42
Electrical conductivity (dS m-1)	0.44
Organic carbon (OC %)	0.38
Available phosphorus (kg P_2O_5 per ha)	17.50
Available potassium (kg K_2O per ha)	212.50

Biochar is rich in carbon. It has higher values of P_2O_5 and K_2O compared to farmyard manure.

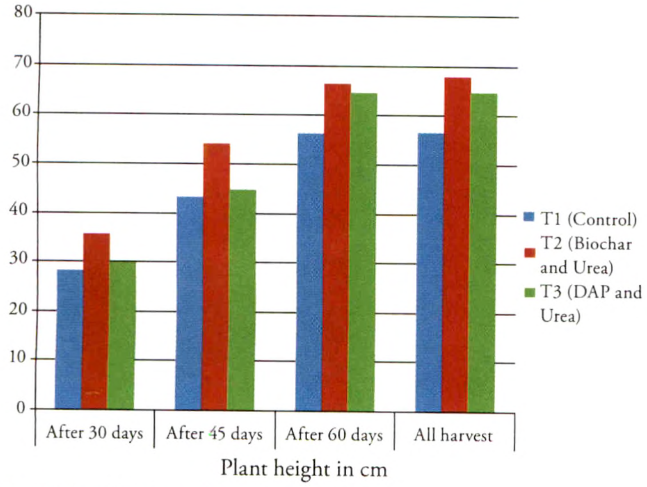

Fig 3. Plant height at different stages of crop

metres above mean sea level at Ankur Scientific Energy Technologies Pvt Ltd, Gujarat. The soil of the experimental site was alluvial, sandy loam in texture. A composite soil sample was analysed and the values have been given in Table 2. The soil is neutral in reaction, medium in available K_2O and low in available P_2O_5.

Field Experiments

The field experiments were laid down in simple plot design with three treatments replicated three times. The plot size was 3mx5m = 15 m^2. The following three treatments were given:

T1 (Control): No fertiliser was used.

T2 (Biochar + Urea): 50 kg per ha P_2O_5 through biochar and 3 splits of 128 kg per ha N through urea ; 1/3 as basal + 1/3 at tillering + 1/3 at milking.

T3 (DAP+Urea): 50 kg per ha P_2O_5 through DAP and 3 splits of 128 kg per ha N through urea; 1/3 as basal + 1/3 at tillering + 1/3 at milking.

Standard agronomical practices were followed in land preparation, fertiliser application, seed sowing, irrigation, after care, harvesting and threshing and the following data was collected during the field experiments:

Plant Height: The plant height of thirty randomly selected shoots in a plot was measured. The measurement was made from the base of the plant to base of the last fully opened/ flag leaf at 30, 45 and 60 days and at harvest and expressed in centimetre.

Ear Head Length: Thirty ear heads were randomly selected from the samples collected from each plot. Ear head length was measured from the base to tip of the ear and expressed in centimetre. These ears were threshed to record the number of grains per ear head.

1000-Grain Weight: Grain samples collected from the net plot grain yield were used for recording 1000 grain weight and was expressed in grams.

Grain and Straw Yield: The total biomass yield for each net plot was recorded at the time of harvest. After threshing, grains were separated, cleaned and weighed. Straw yield per plot was worked out by subtracting total grain weight from total biomass for respective treatments. Later the plot yield was converted into kg per ha.

Plant Growth and Yield

Plant Height: The data on plant height as influenced by different treatments are presented in Fig 3. The plant height progressively increased in all the treatments. However, the growth rate and the total plant height was highest in treatment T2 (Biochar+Urea).

Ear Length, Grains in Ear and 1000-Grain Weight

The data on ear length of wheat at harvest, average grains in each ear head and 1000-grain weight for different treatments are shown in Fig 5. All these growth parameters were highest for T2. This indicates the better growth of wheat grains when P fertiliser was replaced by biochar. The

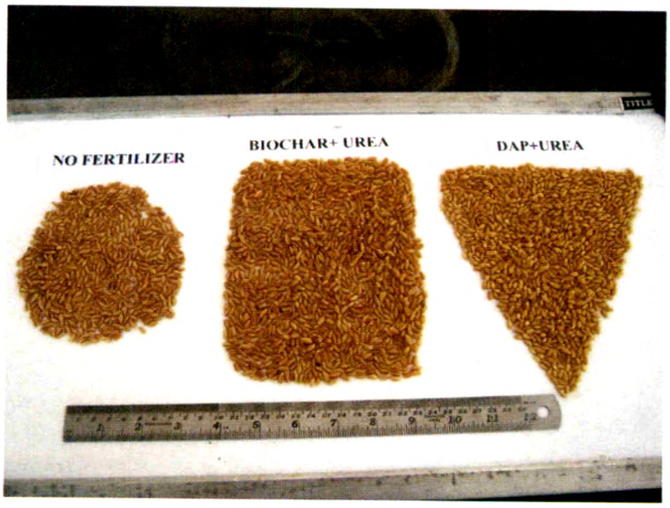

Fig 4: Wheat grain of different treatments

lowest parameters were recorded in treatment T1 where no fertilisers were used. The quality of grains of different treatments is shown in Fig 4.

Grain Yield, Straw Yield and Total Yield

The grain yield, straw yield and total yield of the crop under different treatments are presented in Fig 6. The minimum straw and grain yields were recorded in control experiment treatment T1 which is obvious as no fertiliser was applied. The grain and straw yield in treatment T3 was 6014 kg per ha and 9441 kg per ha respectively. This is obvious as increase in yield is attributed to the use of recommended dose of fertilisers.

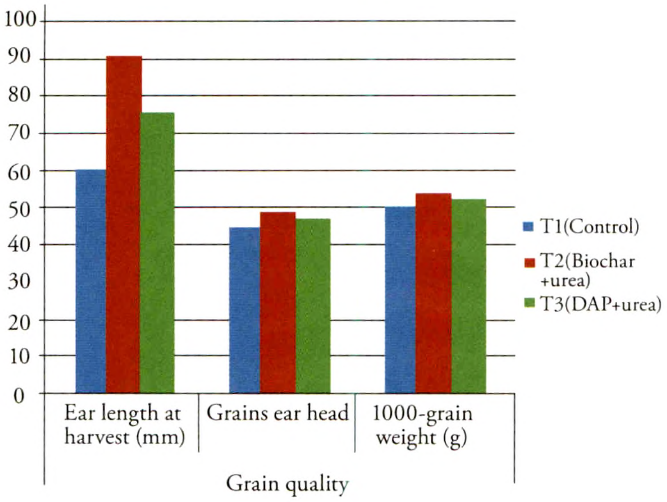

Fig 5. Ear length, grains per ear head and 1000 grain weight

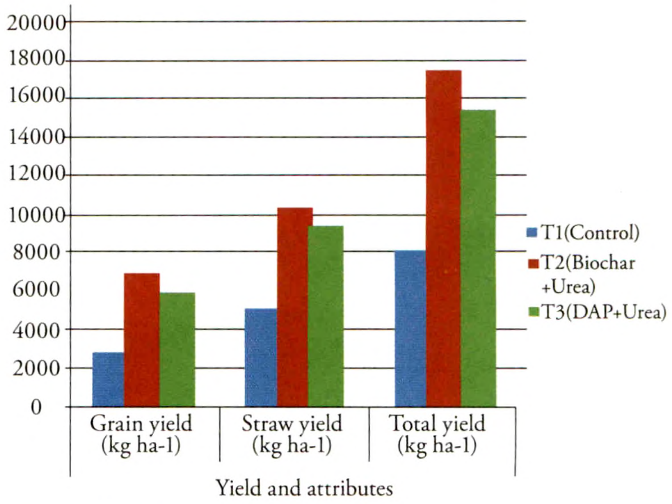

Fig 6. Grain yield, straw yield and total yield

The maximum grain yield of 7112 kg per ha was recorded in the treatment T2 wherein biochar was used as substitute for di-ammonium phosphate (DAP). The grain yield in treatment T2 was about 18 per cent higher than that of treatment T3. Similarly, straw yield at 10308 kg per ha was also significantly higher in T2 compared to T3. The higher yields of grain and straw in T2 compared to T3 may be attributed to the positive effect of biochar. All yield indices indicate that growth was highest in treatment T2 compared to treatments T1 and T3.

> **Life cycle analyses show that biochar application in soil can reduce CO_2 emissions.**

Conclusion

Studies on biochar have shown that a combined use of biochar and fertilisers have increased grain yield as well as straw yield. There is a great scope for biochar to be used as an alternative to fertilisers. It is a step forward towards flourishing agricultural growth, when there is the urgent need for high yield/production that favours cost cutting and paves the way for a sustainable future that secures the interests of the masses as a whole, and the agricultural sector in the country, in particular.

Application of biochar alone or in conjunction with fertilisers is known to favourably alter the chemical, physical, and biological conditions of some soils thereby increasing the yield. Life cycle analyses show that biochar application in soil can reduce CO_2 emissions. Studies on combined use of biochar and fertilisers application have shown increased yield of wheat and decreased use of fertilisers. If biochar application to soil enables decreased fertiliser use, this may further reduce emissions from the manufacture of fertilisers and would mean financial savings to farmers since the cost of biochar application is less. The future of the agricultural sector in India faces grim circumstances owing to food security and thus methods like biochar will go a long way in heading toward substantial development along with maintaining environmental norms. ✪

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Moving Towards a Green Future

The Gujarat Energy Development Agency or GEDA is playing a stellar role in the development of long term renewable energy and energy efficient technologies in the state of Gujarat.

Daksha Vaja

Windfarm at Village Koorunga,Taluk Jamjodhpur, Jamnagar

As the world witnesses a growth in the demand for clean energy, Gujarat recognises green energy as one of its focus sectors. It has emerged as a leader of India's future energy programme with its constant emphasis on mitigation initiatives by exploiting the clean and green power generation potential of wind and solar energy.

GEDA: The Renewable Mandate and Rationale

The GEDA has been making strides as an organisation in helping Gujarat tap its green energy potential. The following are its mandate:

- Foster the development of sustainable, equitable and resilient energy systems suitable for India's developing economy.

- Initiation of change from energy deprivation and dependence to energy autonomy through use of renewable technologies and energy conservation measures.
- Create energy literate citizenry, capable of making wise energy choices.
- Research, development, demonstration and popularisation of renewable energy and energy efficient technologies.

To create opportunity for people to improve their lives by:

- Promoting open and competitive markets for renewable/ sustainable energy power projects in Gujarat.
- Supporting companies and other private sector institutions where there is a gap through a single window clearance
- Helping to generate productive jobs and deliver essential services to the renewable energy sector.
- Catalysing and mobilising the promotion and popularisation of sustainable energy technologies through various outreach programmes and projects.

Gujarat: Renewable Energy Potential

Gujarat is rich in renewable energy resources. With 300 days' sunshine and vast tracts of wastelands, even if 1 per cent of the land mass is set aside; it has the potential to generate 10,000 MW of solar power. Its 1600 km coastline, the longest in the country, can generate 10,000 MW of wind power and the 24 million tonnes of biomass produced has the potential to generate 900 MW of electric power. The 200 lakh cattle population can produce 5.6 million cu m of biogas daily at 70 per cent dung collection efficiency that can cater to the cooking gas requirement of 2.8 million families or generate 933 MW of power. Additionally, the tracts of 67 lakh ha of wasteland can yield 67 million tonnes of biomass that has the potential to generate 15000 MW of power. The tidal potential of the sea is at 900 MW and that of the Gulf of Kutch is at 900 MW whilst the energy conservation potential is 23 per cent.

Gujarat: Realising Solar MW Capacity

Gujarat has converted its challenges into opportunities and is the first state in India and the fourth province in Asia to set up a separate Department of Climate Change. The State Government of Gujarat took a bold initiative and announced its Solar Power Policy in January 2009, allowing investors to set up MW-scale solar power projects within the State, assuring the purchase of power generated through the solar power plants at a levelised tariff of Rs. 12.58 kW. The price payable was pegged at Rs. 15 per kW for the first 12 years and Rs. 5 for the next 13 years.

> **The State Government of Gujarat took an initiative and announced its Solar Power Policy in January 2009, allowing investors to set up MW-scale solar power projects within the State at Rs. 12.58 kW.**

PUPU 1 MW Solar Power Project

The Policy received an overwhelming response from across the globe, resulting in the allotment of capacity close to 1 GW to over 85 national and international developers. And in this continued effort to combat environmental degradation and promoting clean energy, the State has received investments worth Rs. 61289 crore through the 66 MoUs signed at the Vibrant Gujarat Global Investors Summit (VGGIS) for setting up 7761 MW power generation projects in the renewable energy sector.

By December 2011, power purchase agreements (PPAs) for projects aggregating a capacity of 971.5 MW were signed. Of the allotted capacity, as of March 2012, solar power capacity of 600 MW has been commissioned and another 370 MW is likely to be commissioned within the next few months. The State has emerged as the largest solar power producer with its share of 600 MW which is two-thirds of the country's total generation at 800 MW, as of March 2012.

The Gujarat Solar Park, set up with an investment of Rs 9,000 crore by private companies is spread across a desolate 3,000-acre (1,200-hectare) swath of desert, and can supply 214 megawatts of electricity daily from a single location, making it larger than China's 200-megawatt Golmud Solar Park. Its foundation stone was laid down in December 2009 and the State government plans to set up solar power manufacturing, assembling, research and development

Asia's largest solar power park, set up at village Charanka in Patan district in April 2012, across a desolate 3,000 acre of desert, can supply 214 megawatts of electricity daily.

Charanka Solar Park Model

facilities in addition to a manpower training institute envisaged to train local people and create job opportunities.

Shri Narendra Modi, Chief Minister, Gujarat inaugurated the Asia's largest solar power park, at village Charanka in Patan district in April 2012. Patan which is home to the Patola textile craft now also houses the solar park. In 10 other districts, where similar but smaller projects were conceived, another 390 MW is being produced using the virtually inexhaustible source of renewable energy.

The 1 GW solar power plants will annually generate 1554 million units of green power, reduce 1.55 million tonnes of carbon dioxide emissions and help avoid the use of 1.09 million tonnes of coal that would have gone into generation of electricity through coal. These power plants would bring in an annual employment generation of 5000 jobs besides other ancillary activities. The average electricity generation is in the range of 5000 - 5500 kW per MW per day, which is close to the estimated generation.

Wind Power: The Big Player

Gujarat with the longest coastline in the country and inland windy sites has a potential of over 10,000 MW of wind power. Over a period of more than 25 years, more than 65 sites have been monitored for wind speed and wind power density, and over 50 sites have been found feasible for harnessing of wind power. In fact, Gujarat was the first to set up the largest demonstration windfarm of 10 MW at Lamba, in Jamnagar in 1990. Demonstration windfarm projects of 16.295 MW were established with financial assistance from the Centre and the state. The experience gained by the early demonstration windfarm led to the formulation of the first of its kind Wind Power Policy in the country, by Gujarat in January 1993 followed by revised policies in 2002, 2007 and 2009. Since then the capacity additions as of March 2012 is 2884.850 MW of wind capacity. These windfarms have generated 13,450 million units of clean energy, as a result, of which the use of 9.4 million tonnes of coal was avoided and carbon dioxide levels were reduced by 13 million tonnes.

On the wind technology front, refinements of existing designs have focused on drive-train improvements to reduce costs and increase reliability, on the one hand and enhance the size of wind turbines on the other. Gearless turbines have been introduced by several manufacturers - though at present it is only 10 per cent of total turbines production, it is growing substantially. Other areas of research have included higher grid penetration and expansion, storage and wind forecasting.

Renewable Energy Certificates: Ensuring Trading

The National Renewable Energy objectives require a projected channelising of 115 billion units of renewable power into the grid by 2014-15. Renewable Energy Certificates (RECs) will be a key driver in achieving these objectives. RECs are market-based instruments that provide renewable energy generators, an alternative to the prevailing feed-in-tariff regime. They are also a means for distribution utilities to meet their renewable purchase obligations (RPOs). At a macro level, the launch of the RECs is important for achieving the targeted renewable energy share of 10 per cent by 2015. Gujarat already has over 300 MW of renewable energy grid-connected projects under the REC mode, wherein the power produced is sold to the distribution licensee at the average pool purchase cost of Rs. 2.64 per kW, while the environment attributes are traded in the power exchanges set up for this purpose.

Biomass Power Generation: The Energy Next

Besides solar and wind energy, the State is also committed to harness the biomass energy potential of over 1200 MW. Currently, 31.2 MW of biomass-based power plants based

Gujarat: Showcasing Renewable Energy

- 1988-89: National Shield for Best Overall Performance by MNRE, New Delhi
- 1988-89: Outstanding Performance in Solar Thermal Programme by MNRE, New Delhi
- 1989-90: National Shield for BEST Overall Performance by MNRE, New Delhi
- 1989-90: Outstanding Performance in Solar Thermal Programme by MNRE, New Delhi
- 1990-91: National Shield for BEST Overall Performance by MNRE, New Delhi
- 1990-91: Outstanding Performance in Solar Thermal Programme by MNRE, New Delhi
- 1991-92: 2nd Best Performance in Biomass Programmes by MNRE, New Delhi
- 1993-94: 2nd Prize for Windfarms Development by MNRE, New Delhi
- 1994-95: 2nd Prize for Windfarms Development by MNRE, New Delhi
- 1995-96: Outstanding Performance in Solar PV by MNRE, New Delhi
- 1995-96: 2nd Best Performance in Windfarm Development by MNRE, New Delhi
- 1997-98: Overall Best Performance in Information and Publicity by MNRE, New Delhi
- 2000-01: Overall Best Performance by MNRE, New Delhi
- 2001-02: 1st Prize for Solar Cooker Promotion by MNRE, New Delhi
- 2002-07: Overall Best Performance in Solar Cookers Programme by MNRE
- 2006-08: Best Wind Developer State by WISE, Pune, New Delhi
- 2009-10: Best Case Study on Wind Energy by Renewtech Foundation, Pune.
- 2011-12 Century International Quality Award in Gold Category Business Initiative Directions, Spain.

on agricultural residues are being converted to energy through the combustion and gasification route in Amreli, Junagadh,Bhavnagar and Vadodara.

Sustainable Initiatives: Highlights

- Gujarat aiming to be the solar capital of the world.
- First State in the country to announce a Solar Power Policy with targets and implementation mechanism. The State today leads in the implementation of solar power projects.
- 85 investors signed PPA for setting up 971.50 MW solar power projects.
- Asia's first 500 MW Solar Power Park at Charanka, District Patan.
- Asia's first State to set up a separate Department of Climate Change.
- Gandhinagar declared as the Model Solar City by Ministry of New and Renewable Energy (MNRE).
- 604.89 MW of grid-connected solar power projects commissioned.
- A one MW grid-connected solar power plant at village Chandrasan, District Mehsana on the Narmada Canal is an engineering innovation as it serves the triple purpose of generation of clean energy, annually reducing 90,000 litres water evaporation from the canal as well as avoiding use of precious land for the solar power plant.
- 2884.85 MW Wind Power Projects commissioned on the coast of Saurashtra and Kachchh.

> **First State in the country to announce Solar Power Policy with targets and implementation mechanism. The State today leads in the implementation solar power projects.**

- 5 MW Solar PV Roof Top Scheme announced in the cities of Rajkot, Surat, Bhavnagar, Mehsana and Vadodara.
- 31.2 MW capacity biomass projects commissioned in Amreli, Junagadh, Bhavnagar and Vadodara.
- 13.229 MW waste-to-energy power generation projects.
- Institutional biogas plants of 8380 cubic metre per day capacity in various institutions across the State.
- LED Village, Amarpura, Gandhinagar.
- First state to implement energy efficiency in agricultural pumping sector.
- 60 MW load reduction through 11,000 energy efficient pumping sets.
- Bal Urja Rakshak Dal: Since 2004, the GEDA has been annually **mobilising** a force of 50,000 secondary school students as Urja Rakshaks and 3600 school teachers as Urja Agevan, to make wise energy choices through energy conservation. ✪

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BIOGAS
from Kitchen and Food Waste

An experimental biodegradable waste fed biogas plant at a hostel in Tamil Nadu becomes an effective tool to serve the power supply needs of the institution.

P Venkatachalam & S Kulanthaisami, P Subramanian

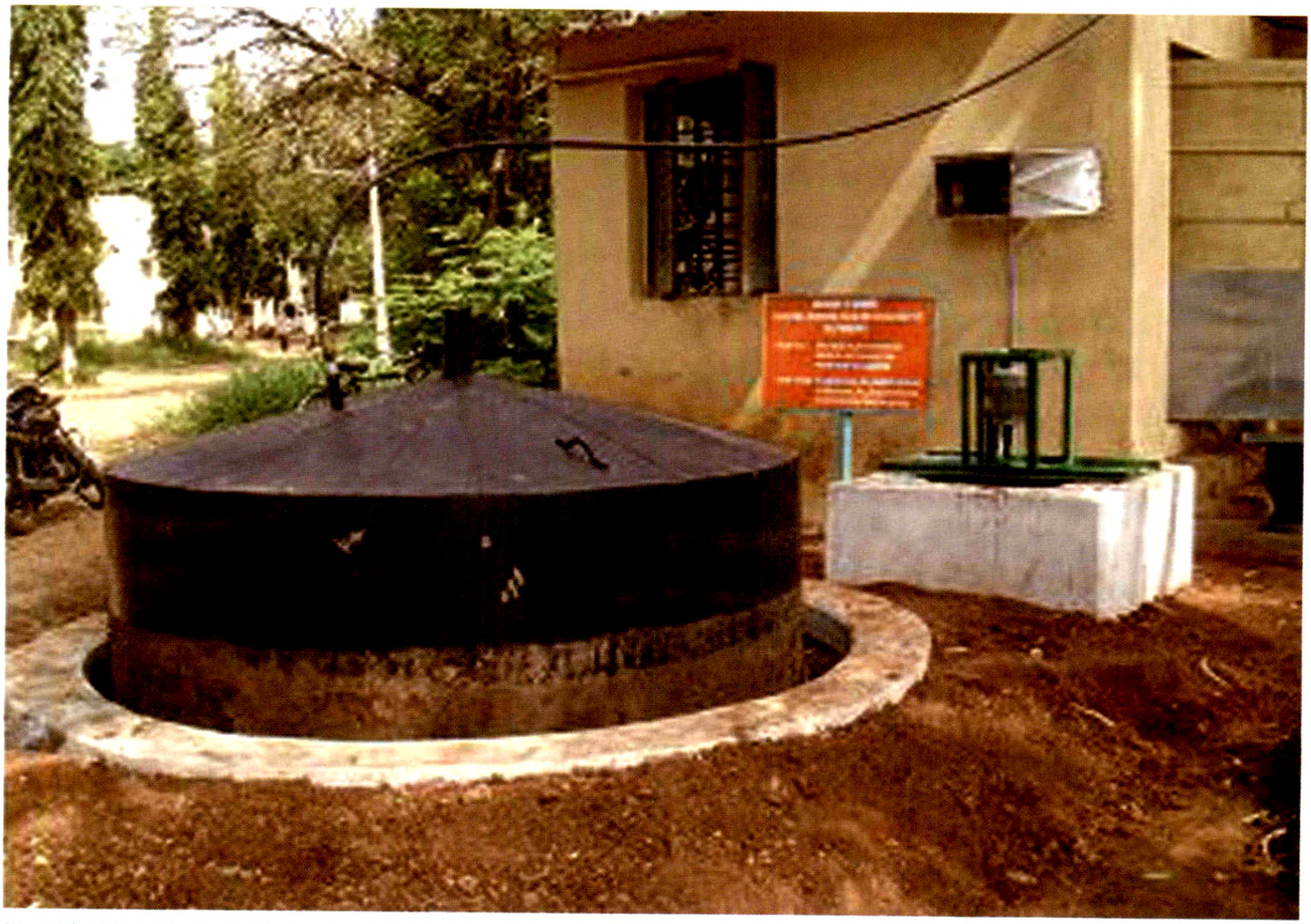
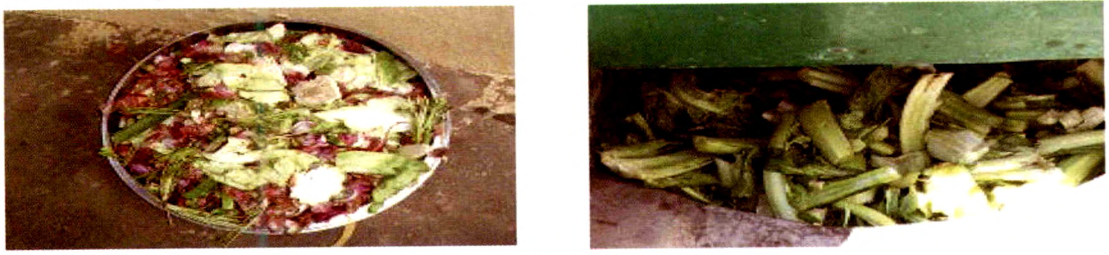


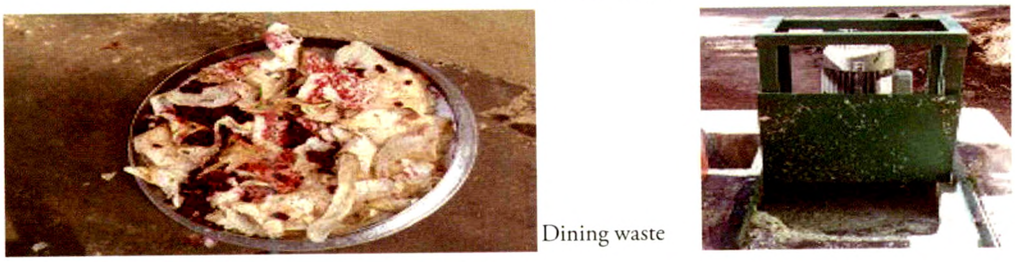
Fig 1. The 10 cubic metre kitchen and waste biogas plant installed at TNAU hostel

Seeing the burgeoning fuel requirement for running an institution of its size, the Tamil Nadu Agricultural University (TNAU), decided to look within to find resources to generate fuel for its own energy needs. It was noticed that the institution's hostel's kitchen and dining halls were generating a great deal of food, vegetable and other biodegradable wastes. The usual practice of disposal was to throw it or use it as animal feed. However, this was not economical and was certainly not helping to solve the problem of waste disposal. Thus as an answer to this, a 10 cubic metre kitchen and dining hall waste based biogas plant was installed at the students'

Fig 2. Kitchen and dinning waste mixing



Kitchen waste



Dining waste

Kitchen and dining waste after mixing

hostel (Fig 1). The plant was conveniently located near the waste discharge point of the students' mess and the daily vegetable and dining waste generated, an average of 20-30 kg and 60-70 kg, respectively, was directed into the plant for processing.

The plant was constructed in brick with a 3.5 m long reinforced cement concrete (RCC) slab in the centre, placed to hold the drum. The whole plant was plastered with a cement-mortar mixture in a ratio of 1:2. The gas holder of 2. 2 m diameter and 1.2 m height was fabricated with a 3.16 mm thick mild steel (MS) sheet and a gas outlet pipe was connected with the gate valve. A stirrer arrangement was made within the inlet tank for proper cutting, stirring and mixing of the waste (Fig 2). An inlet pipe made of polyvinyl chloride with a diameter of 30 cm and length of 2.05 m, fixed at an angle of 75° to the horizontal for easy flow of the mixed waste feed, was used.

The plant was loaded after curing it with a mix of 6 tonnes each of cow dung and water to maintain the initial total solid content of 10 per cent. It was allowed to stabilise for 40 days and during this period, it was regularly fed with cow dung and water mixed in a ratio of 1:1. After stabilisation, in the first week, the cow dung usage was reduced to 90 per cent and the kitchen and dining waste was added as the remaining 10 per cent. Subsequently, 10 per cent cow dung was reduced and 10 per cent of waste was increased every week. And by the tenth week, the plant was running 100 per cent on kitchen and dining waste (Table 1).

Table 1. Feed combination of kitchen and dining waste and cow dung .

Kitchen and food waste (%)	Quantity of kitchen and food waste (kg)	Quantity of cow dung (kg)	Water addition (l)
0	0	150	150.0
10	7.5	135	142.5
20	15.0	120	135.0
30	22.5	105	127.5
40	30.0	90	120.0
50	37.5	75	112.5
60	45.0	60	105.0
70	73.5	45	118.5
80	60.0	30	90.0
90	67.5	15	82.5
100	75.0	0	75.0

The average monthly biogas gas production has been observed in the range of 5.61 to 5.84 cubic metre per day and the gas production rate is observed to be constant. The biogas produced is utilised in the hostel kitchen for about 6 to 6 ½ hours per day for cooking. The rated input capacity of the plant is 70 kg/day and depending upon the availability of the feed, it varies from 50 to 80 kg/day.

The net savings on fuel are estimated to be 3 to 4 LPG gas cylinders per month which means that Rs. 3000 per month towards LPG cost is saved due to the installation of the biogas plant. Annual savings are estimated at around Rs. 36,000. The simple payback period has been worked out to be 3 years. It is by far the best technology for the treatment of kitchen and dining waste because it not only generates energy from waste but also solves the problem of waste disposal.

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Creating Wealth from Organic Waste

Pune Municipal Corporation
Bio-Methanation-cum
Power Generation Plant
To Treat 5 Tons Per Day Segregated
Organic Municipal Solid Waste At
Ward No-34 (Model Colony) Pune
ENPROTECH SOLUTIONS
Environmental Protection Technologies
Based on BARC's NISARGRUNA Tech.
Designed, Engineered & Executed By : Enprotech Solutions, Pune

Pune Municipal Corporation has taken a remarkable step in developing a municipal solid waste biomethanation plant that serves not only in generating power but also helps in the organising and disposal of waste in the city.

In today's energy deficit world, where conventional sources of energy are fast depleting and at a time when recycling and optimum utilisation of resources is the need of the hour, the city of Pune is setting an example through its biomethanation plant. It is a known fact that municipal solid waste (MSW) generation in Pune, is among the highest in Indian cities with an average of 0.400 kg (0.294 - 0.540 kg) of waste being generated per person per day. Pune's current population is 40 lakh and the city generates about 1300 metric tonnes of MSW per day. The source wise broad composition of solid waste generated in the city is as follows - commercial - 25 per cent; market area - 5 per cent; hotels and restaurants - 25 per cent; and vegetable market - 5 per cent; household - 40 per cent. What's interesting is that the organic and biodegradable portion of the solid waste is 70 per cent which is a significant consideration in the concept of solid waste management. The basic idea behind setting up a biomethanation plant was to treat the organic waste in a decentralised manner, at its source, in the most environmentally efficient way. Currently, the overall MSW collection and transportation efficiency is 80-90 per cent of which 45 per cent is segregated. The Pune Municipal Corporation or the PMC has allotted separate vehicles for the collection of the segregated wet waste which is 300-350 tonnes per day (Table 1). This helps the PMC save on transportation costs of such wastes to the landfill site which is 22 km away from the model colony area.

Table 1. Expected biogas, electricity and manure generation

i	Plant capacity	1X5 TPD per day segregated organic biodegradable municipal solid waste
ii	Type of process	Biomethanation through two stage process
iii	Biogas generation	300 Cum/day
iv	Electricity generation	375 kW/day
v	Manure generation	500 kg/day (on 50 per cent moisture basis)

MEDA's Initiative

The Maharashtra Energy Development Agency (MEDA) is constantly striving to promote decentralised biomethanation-cum-power generation plants in Maharashtra in urban as well as rural areas. As a part of its initiative, an official visit of Dr. A. R. Shukla, Advisor, Ministry of New and Renewable Energy (MNRE), along with MEDA officials, to the Model colony plant, was arranged on 20 February 2010. Post this visit, it was decided that all such decentralised biogas plants in urban areas ought to be considered for Central Finance Assistance (CFA) under the Biogas-based Power Generation Programme (BPGP) of the MNRE, to boost the promotion of such projects. The PMC has installed 11 such biogas to power generation plants at various locations in Pune and is planning to set up many more such projects in the city.

> **The solid wastes generated in urban areas from vegetable markets, hotels, hostels, kitchen wastes etc. are best suited for this process due to their high moisture content and organic fractions (up to 90 per cent).**

Biomethanation Process

A major portion (40-60 per cent) of this waste is organic in nature and can be easily treated by anaerobic digestion. The solid wastes generated in urban areas from vegetable markets, hotels, hostels, kitchen wastes etc. are best suited for this process due to the high moisture content and organic fractions (up to 90 per cent). The total solids in the organic waste decompose rapidly (i.e. are highly putrescible) and therefore these wastes can be treated by the biomethanation process, more commonly called anaerobic digestion.

The biomethanation plant at Model Colony is based on the two-stage anaerobic process. The sizes of the digesters for the first stage and the second stage are decided on the basis of the suspended organic contents of the slurry to be treated. The first stage fermentation is the hydrolysis stage and the second is the methanation and polishing stage. The first stage is designed to give maximum solid retention time for the hydrolysis and the second stage for acidification and biomethanation process operate in the mesophillic range.

In this process, the wet waste generated within the model colony area (from household kitchens, commercial complexes, hotels/restaurants, fruit and vegetable markets wet wastes etc.) is collected and brought to the plant site by the PMC. Though, it is segregated wet waste, it still contains 2-5 per cent non-biodegradable material, such as plastics, glass, metal etc. All such material is removed manually in the first stage, known as 'fine segregation'. Thereafter, the segregated wet waste is mixed with water in 1:1 proportion and crushed in the shredder to convert it into slurry, before being fed to the primary digester. The slurry is then treated in closed vessels called anaerobic digesters (primary and secondary digesters) where, in the absence of oxygen, microorganisms break down the organic matter into a stable residue, and generate a methane-rich biogas in the process. The generated biogas is cleaned with the help of scrubbers. In the scrubbing process, moisture, hydrogen sulphide and to a certain extent carbon dioxide are brought to an acceptable level and then the purified biogas is stored in a biogas balloon, made up of neoprene rubber. The purified biogas is then supplied to a 40 kVA indigenised biogas engine (run on 100 per cent biogas) to generate electricity. The solid residue which remains after biomethanation process comprising of solid/fibrous material and liquid, is separated in the slurry drying beds. About 50 per cent of the liquid manure is then re-circulated in to the system, as it contains nitrogen and some active anaerobic microorganisms. The fibre contains an organic material, which is being used as manure for the PMC's public gardens.

Project Components

The project includes the following sections:

- Waste reception and fine segregation section
- Mechanical crushers - 2 nos of 5 HP (horse power)
- Two stage anaerobic reactors - 200 cubic metre. In building-block methodology (BBM) - with aeration, biogas and leachate recirculation facility
- Manure handling section - 35 sq m in BBM
- Biogas collection section - 2 nos of 75 cubic metre each in neoprene rubber with enclosure
- Biogas cleaning system - CO_2 and H_2S scrubbers, pressure vessel and vacuum pump.
- Power generation - 40 kVA, 100 per cent biogas based Indian engine.
- Recirculation system.
- Solar water heating system - 500 lt/day

Advantages

Apart from the fact that the biogas produced is effective in reducing harmful greenhouse gas emissions, the compact design of the plant makes it convenient for use and utilises less footprint area. The treatment of organic solid waste is

Table 2. Plant economics (Till 28th February 2012)

1	**Total Inputs**	
1.1	Total wet waste fed to the plant from 1st November 2009 to 31st December 2011.	4000 Tonnes
2	**Total Outputs**	
2.1	Electricity generated (with 22 kW load and 250 street lights).	68000 kWh - operate biogas engine during day as well to generate electricity, which is being used for carrying out feeding operations.
2.2	Total manure generated	340 tonnes
3	**Total Savings**	
3.1	Savings due to electricity generation	68000 kWh X 5.00 Rs./kWh = Rs. 3.4 lakhs
3.2	Savings due to manure generation	340 tonnes X Rs.1000 Rs./tonnes = Rs. 3.4 lakhs
3.3	Savings in transportation of wet waste to the landfill site	4000 tonnes X Rs. 650 Rs./tonnes = Rs. 26 lakhs PMC is currently spending Rs.1300 per tonnes to collect, transport and to dump the waste at Devachi Urli Landfill site. Even if, it is considered that due to this plant they are going to save at least 50 per cent of the transportation cost, The annual savings (for 330 days) works out to Rs. 10.72 lakhs per annum respectively.
3.4	Total Savings	Rs. 32.8 lakhs
4	**O&M cost for 28 Months**	**Rs. 12.2 lakhs**
5	**Net savings for 28 months**	**Rs. 20.6 lakhs**
6	**Net annual savings**	**Rs. 8.82 lakhs**
7	**Payback period with the current performance / economics.**	**6½ years from the date of commissioning of the Plant.**

done in a closed vessel hence there is no odour and organic matter is recycled to generate nutrient-rich manure.

Indirect Benefits

Indirectly too, the benefits for the PMC are many. Apart from providing better hygienic conditions to the citizens of Pune, the plant will go a long way in increasing the operational life of existing sanitary landfill. It will help avoid the release of methane gas (from uncontrolled open dumping at landfill sites) into the atmosphere, which can cause serious environmental damages. In other words it stalls the release of 180 cubic metre of methane (which is 22 times more potent than CO_2) per day into the atmosphere. Further it reduces the release of CO_2 since there is a reduction in the use of transportation fuel. The energy/income positive treatment process ensures self sustainability and the project can avail Clean Development Mechanism (CDM) benefits.

Table 3. Month wise details of wet waste fed to the biomethanation plant

Month	Feeding Qty.	Cumulative Feeding	Per cent of Total Feeding Capacity of 150 TPM
	Tonnes/Month	Tonnes	Tonnes/Month
November 2009 - March 2010	734	734	81.4
April 2010 - March 2011	1730	2464	96.13
April - 2011	156	2620	103.85
May - 2011	144	2764	96.27
June - 2011	149	2913	99.44
July - 2011	165	3079	110.20
August - 2011	162	3240	107.83
September - 2011	160	3400	106.63
October -2011	146	3546	97.43
November - 2011	154	3700	102.65
December 2011	174	3874	115.97
January - 2012	160	4034	106.51
February - 2012	142	4176	94.67
Total	**4176**		**101.46**

TPM - tonnes per month

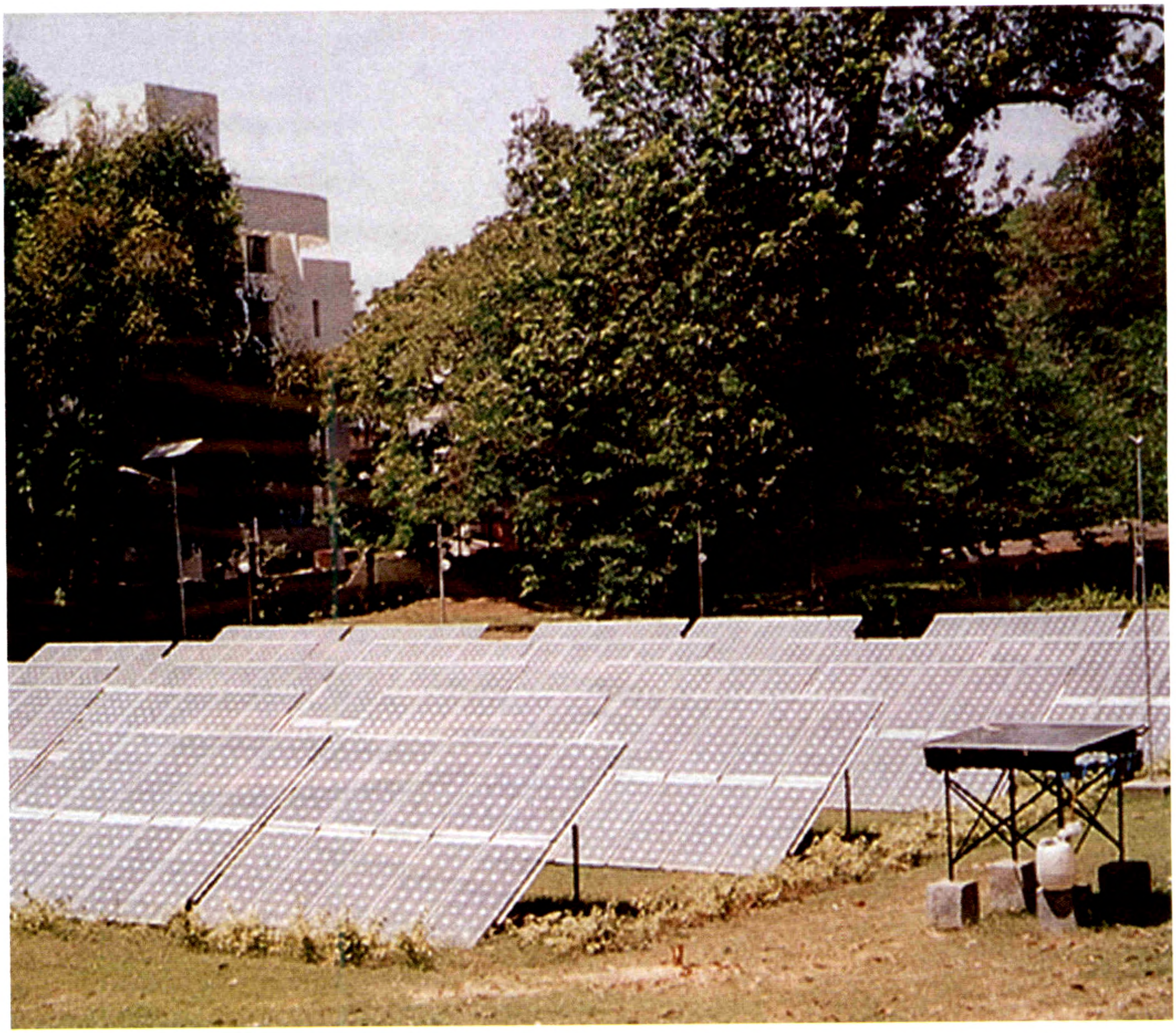
Present Status

The biomethanation plant has been operational since November 2009. The connected electricity load is 22 kW and 250 street lights (mix of 70 / 100 / 250 W lights) in the Model Colony area are lit for 10-11 hours daily. As of 28 February 2011, the biogas engine had completed 7200 hrs. (Table 2.) of operation and generated 68000 kW of electricity. Further, the month wise details of total wet waste fed to the plant by the end of February 2012 are shown in Table 3. ○

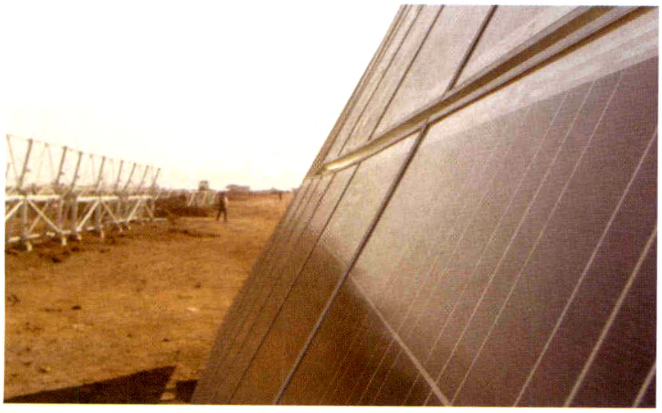
Courtesy: Prafulla Tayde, Maharashtra Energy Development Agency (MEDA). Email: prafullatayde@gmail.com

Solar Electricity at GERMI

Gujarat Energy Research Management Institute (GERMI) has paved a way towards using solar power sustainability by commissioning a 5 MW solar PV project for Gujarat Industries Power Company Limited



Gandhinagar, has successfully commissioned a 5 MW solar PV project for Gujarat Industries Power Company Limited (GIPCL), Vadodara, on 26 January 2012. The GIPCL is a Gujarat based electricity generating company whereas the GERMI is a Department of Science and Industrial Research (DSIR) approved research institute engaged in the field of advance level research in petroleum, solar and nuclear energy, climate change and also offers training and consultancy services to the industry. This ambitious project of the GIPCL materialised with strong technical and project management support provided by the GERMI.



GIPCL 5 MW Solar PV Power Plant with 'GERMI seasonal trackers'

The GIPCL solar plant was located atop the external dump at village Nani Naroli, district Surat. The location was at a height of 98 m above mean sea level (MSL) and about 45 m from the surrounding area. Further the dump was essentially a collection of loose soil of mining excavation work and therefore offered very poor load bearing capacity (safe bearing capacity (SBC)<<10). This posed a real challenge to GERMI in designing and executing civil foundations. The module mounting structure had to be customised to adopt a seasonal tracking mechanism so as to enhance the plant's generation. Moreover, unlike the other projects which generally are executed by an Engineering Procurement and Construction (EPC) contractor, the GIPCL project was executed through the 'package route'. The concept of a package route essentially involves helping the project developer gain first-hand experience of constructing a solar project by directly dealing with vendors or original equipment manufacturers (OEM) to supply all key equipment to the end user, namely the project developer. The plant will be assembled by either the project developer or by a contractor appointed by the project developer. It is anticipated that the package route can reduce the margins in between the vendors and the EPC and can significantly reduce total project cost.

Following the GIPCL's requirements, the GERMI designed individual packages, prepared and executed bids for selection of vendors and developed the civil foundation. Further, in order to enhance the energy generating capacity of the said plant, the GERMI designed seasonal tracking structures which would help generate at least 5 to 7 per cent more electricity when averaged out over the entire year. Accordingly, six contractors were awarded the work order to supply key materials and carry out important site activities like civil and building works, erection and commissioning of switchyard and the plant integrator for assembling and finally commissioning the plant.

Thus the entire project was successfully executed through the package route. The plant is now operative since 26 January 2012. It is expected that because of seasonal tracking, this plant will run at a minimum performance of 78 per cent during all weather conditions even after excluding additional generation gain. Thus the plant will export approximately 8496 MW of electricity, offsetting 7646 tonnes of carbon dioxide every year.

It is pertinent to note that despite the exorbitant cost of civil and structural work, there was a reduction of 10 per cent in the final project cost due to the package route. The GIPCL appreciated the GERMI's success in getting the project commissioned well within the tariff regulation period which was due to end on 28 January 2012. The GIPCL has always had a very strong technical team for executing and operating conventional power plants and now in partnership with the GERMI, it is handling solar power projects as well. The GERMI is now looking forward to promote the concept of package route on various projects, to bring down the overall cost of power generation. ❂

Courtesy: Sagarkumar M. Agravat, Solar Research Wing, GERMI.
Email: Sagar.A@germi.res.in

Ministry of New and Renewable Energy

"PRAKRITIK URJA PURASKAR YOJNA"

Ministry of New and Renewable Energy, Government of India, is operating 'Prakritik Urja Puraskar Yojna' to encourage original book-writing in Hindi or translation of books in Hindi in the field of New and Renewable Sources of Energy. Under the scheme, there is a provision for prize money. All authors, whether Government employees or Non-Governmental persons, can participate in the scheme.

For further details, please contact Dy. Director (OL),
Ministry of New and Renewable Energy,
Block No. 14, C.G.O. Complex, Lodi Road, New Delhi-110003
(Phone No. 24362356) or visit this Ministry's website www.mnre.gov.in

Scaling Up Off-Grid Renewable

Ashden India Sustainable Energy Collective

A group of experts comprising of AISEC members provided important insights on application of crucial technology and execution of policies streamlined for renewable energy.

The Ashden India Sustainable Energy Collective (AISEC), a group of 16 India-based winners of the International Ashden Awards for Sustainable Energy believes that practitioner groups such as the AISEC have a critical role to play in bridging the gap between practice and policy. The AISEC members represent a rich body of experience in several areas offering bundled RE solutions for communities. As a part of its endeavour to continue and strengthen its engagement with sustainable energy policies, the AISEC organised three policy round tables between October and December 2011.

The discussions at the round tables highlighted the slow growth of off-grid renewable energy vis-à-vis conventional energy and grid-connected renewable energy, as well as its own inherent potential. The main purpose of the discussions was to identify gaps in off-grid renewable energy (RE) regulation in India, and make practical and implementable recommendations on how to overcome these gaps.

The major barriers for rapid development of off-grid RE in India were identified as: off-grid RE not mainstreamed in Indian energy policy and a public perception that grid electricity is the only acceptable form of electricity; lack of a cogent regulatory framework to mainstream off-grid RE; large subsidies disbursed with little regard to whether they are reaching the target population, incentivising RE or improving energy access; standards for RE devices that are either non-existent or are not suited to spur innovation; no efficient mechanism to make finance available at various levels, for both the end user and entrepreneur; and, energy access not recognised as an essential right and not sufficiently integrated with larger developmental goals.

off-grid renewables : Policy impact Roundtable
The Ashden Indian Collective

There is a need to develop standards for off-grid RE products, suppliers and service providers, in consultation with experts from academia, industry associations and field practitioners, to include-standards to reflect consumer-relevant parameters like quality and output e.g., for solar lanterns standards to be based on lumens over the life of the device rather than watt; development of star rating system for RE consumer products like solar lights, solar water heaters and, cook stoves, biogas plants similar to Bureau of Energy Efficiency (BEE) star rating for electrical consumer durables; development of accreditation process for suppliers; rating and monitoring system for service providers to ensure standards in long term servicing of the systems; approved laboratories and institutions to provide third party standard certification for products and services; and, consumer education on the system of standards. Further, technology specificities must be factored in while reviewing and designing incentives – e.g. biomass-based systems may need to have subsidised fuel or a feedstock price escalation clause and small hydro systems will require a significant component for storage. Also region specific incentives for renewables need to factor in local resource endowment. For instance, states with lower solar radiation may be provided a higher level of subsidy to facilitate the diffusion of solar technologies across the country. An alternative view is to prioritise renewable energy technologies (RETs) for various locations based on resource endowment and then provide incentives in line with these regional RE priorities. Certain end-uses or services may be prioritised based on their importance for the community as well as expected benefits to the community and/or to the environment. ❂

Courtesy: Rekha Krishnan, Independent Researcher, AISEC. Email: rekhak.work@gmail.com

Solar Cell that also Shines: Luminescent 'LED-Type' Design

To produce the maximum amount of energy, solar cells are designed to absorb as much light from the Sun as possible. Now researchers from the University of California, Berkeley, have suggested – and demonstrated – a counterintuitive concept: solar cells should be designed to be more like LEDs, able to emit light as well as absorb it.

The Berkeley team presented its findings at the Conference on Lasers and Electro Optics (CLEO: 2012), which was held on May 6-11, 2012 in San Jose, California. "What we demonstrated is that the better a solar cell is at emitting photons, the higher its voltage and the greater the efficiency it can produce," said, Eli Yablonovitch, principal researcher and professor of electrical engineering, University of California, Berkeley.

Since 1961, scientists have known that under ideal conditions, there is a limit to the amount of electrical energy that can be harvested from sunlight hitting a typical solar cell. This absolute limit is, theoretically, about 33.5 per cent. This means that at most, only 33.5 per cent of the energy from incoming photons will be absorbed and converted into useful electrical energy. Yet for five decades, researchers were unable to even come close to achieving this efficiency. In fact as of 2010, the highest anyone had come was just a little over 26 per cent.

Owen Miller, a graduate student at UC Berkeley and a member of Yablonovitch's group came across a relatively simple solution based on a mathematical connection between absorption and emission of light.

"Fundamentally, it is because there's a thermodynamic link between absorption and emission," Miller says. Designing solar cells to emit light – so that photons do not become 'lost' within a cell – has the natural effect of increasing the voltage produced by the solar cell. "If you have a solar cell that is a good emitter of light, it also makes it produce a higher voltage, which in turn increases the amount of electrical energy that can be harvested from the cell for each unit of sunlight. The theory that luminescent emission and voltage go hand in hand is not new. But the idea had never been considered for the design of solar cells before now," points Miller.

This past year, a Bay area-based company called Alta Devices, co-founded by Yablonovitch, used the new concept to create a prototype solar cell made of gallium arsenide (GaAs), a material often used to make solar cells in satellites. The prototype broke the record, jumping from 26 per cent to 28.3 per cent efficiency. The company achieved this milestone, in part, by designing the cell to allow light to escape as easily as possible from the cell – using techniques that include, for example, increasing the reflectivity of the rear mirror, which sends incoming photons back out through the front of the device.

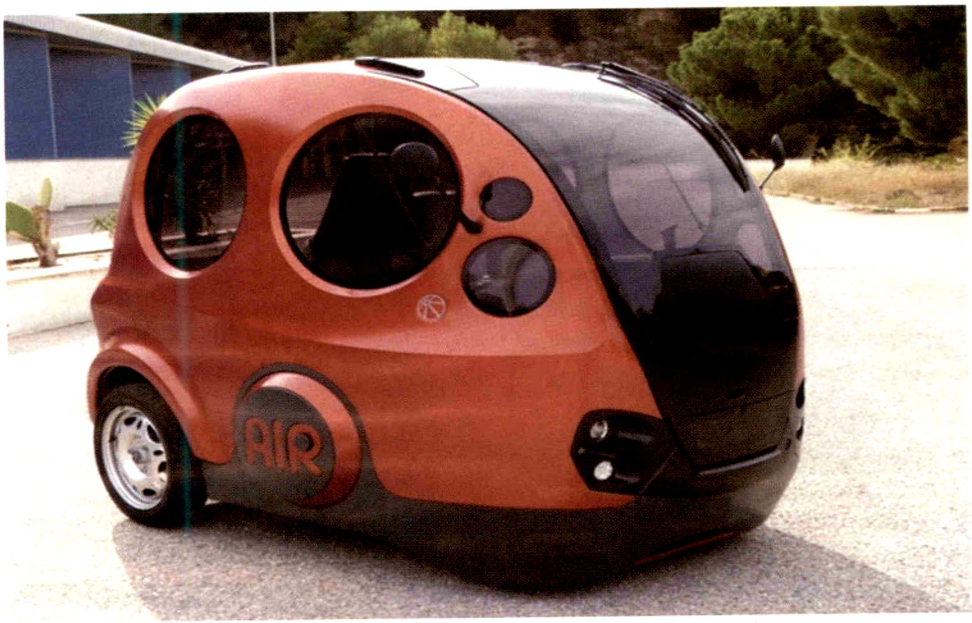
Solar cells produce electricity when photons from the Sun hit the semiconductor material within a cell. The energy from the photons knocks electrons loose from this material, allowing the electrons to flow freely. But the process of knocking electrons free can also generate new photons, in a process called luminescence. The idea behind the novel solar cell design is that these new photons, which do not come directly from the Sun, should be allowed to escape from the cell as easily as possible.

However, mathematically, allowing the new photons to escape increases the voltage that the cell is able to produce. The work is 'a good, useful way' of determining how scientists can improve the performance of solar cells, as well as of finding creative, new ways to test and study solar cells, says Leo Schowalter of Crystal IS, Inc. and visiting professor at Rensselaer Polytechnic Institute, who is chairman of the CLEO committee on LEDs, photovoltaics, and energy-efficient photonics.

Yablonovitch says he hopes researchers will be able to use this technique to achieve efficiencies close to 30 per cent in the coming years. And since the work applies to all types of solar cells, the findings have implications throughout the field. ✪

Courtesy: www.sciencedaily.com

Air-Powered Car now in India



The latest version of the AirPod, a car powered by compressed air

In 2007, Mumbai, India-based Tata Motors signed a licensing deal with Motor Development International, a French design firm. The idea was to build a car that could run on compressed air. Now Tata says it has tested two cars with the engines. The next step is setting up the manufacturing plants to actually build them.

Compressed air engines aren't a new idea. The first models were proposed more than a century ago, and they were used in the mining industry for decades before electric motors became commonplace. Even now, compressed air powers all kinds of tools, notably the pneumatic impact wrenches in auto body shops.

A compressed air car engine works in a way similar to the internal combustion version: Fuel forces pistons to turn a crankshaft and power the car. The difference is that in a compressed air engine, the pistons are moved by air and not gasoline. Researchers in Sweden have experimented with single-cylinder engines of this type.

One of the problems is power. Air compression alone gets a car moving to only about 30 to 35 miles per hour. So to supplement that, the car could take in more air as it moves faster, using an onboard air compressor. The air compressor could be electric or, more likely, gasoline-powered. But even that would reduce emissions a lot, since the gasoline engine wouldn't be running at lower speeds.

Range is also an issue. Like all vehicles, an air-powered car can drive only as far as the amount of fuel in its tank. And storing compressed air requires 'fuel' tanks that are stronger than steel to contain the thousands of pounds per square inch necessary. On the bright side, compressing air in such a tank is a lot less dangerous than natural gas or hydrogen.

Then there is the issue of filling the car's tank – most air compressors would take at least a couple of hours to do that. Tata seems to be the only manufacturer that has committed to actually building an air-powered car. Honda unveiled an air-powered concept car in 2010, and a company called Zero Pollution Motors had promised to deliver one to the United States – but that was two years ago. If Tata is successful, it will go a long way in reducing emissions in India – and perhaps freeing cars from fossil fuels completely. ✪

Courtesy: www.news.discovery.com

GREEN PRODUCTS

Building Green announced its tenth annual Top-10 Green Building Products during the 2011 Greenbuild conference in Toronto. The award highlights the most forward-looking products reviewed in Environmental Building News and featured in GreenSpec throughout the year.

Interface FLOR Carpet Tiles with Non-PFC Carpet Fibres

Interface FLOR carpet tiles with non-PFC carpet fibres contain no perfluorinated compounds (PFCs), which are ubiquitous in other carpet products. PFCs do not readily break down in the environment, and their long-term health and environmental effects are under investigation by the U.S. Environmental Protection Agency and other agencies worldwide as potentially hazardous compounds. The carpet tiles can be specified with high post-consumer recycled content and multiple low-emitting adhesive options.

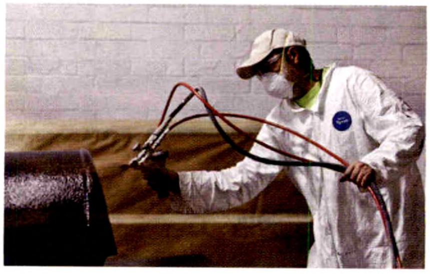
Lifeline PVC-Free Resilient Flooring

Lifeline PVC-free resilient flooring from Upofloor OY (imported by Altro Floors) is made for heavy-traffic commercial spaces yet contains no PVC, plasticisers, phthalates, halogens, or heavy metals. Unlike most commercial resilient flooring, Upofloor has a durable wear layer that minimises the need for maintenance, making it an excellent choice for hospitals, schools, and other buildings where indoor environmental quality is a high priority.

CI-Girt Rainscreen System

The CI-Girt Rainscreen System from Knight Wall Systems helps keep moisture out of commercial building envelopes while permitting continuous insulation over the steel frame—typically an expensive and labour-intensive hand-cutting process when using other rainscreen systems. Since there are no clips, installation time is reduced and there is far less thermal bridging through the insulation.

EonCoat Waterborne Ceramic Coating

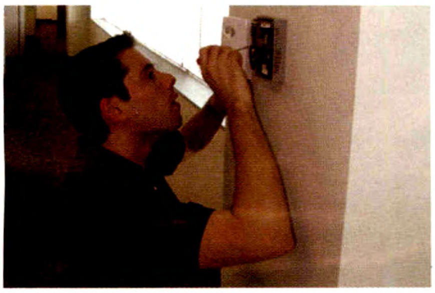


EonCoat waterborne ceramic coating from EonCoat is a truly revolutionary commercial and industrial coating. The water-borne coating has two parts–phosphoric acid and magnesium hydroxide ('milk of magnesia')—that are mixed in the spray valve during installation and set almost immediately. Available in many colours, EonCoat contains no VOCs and no hazardous air pollutants and has zero flame spread–without the use of a flame retardant.

Aqua2use Graywater System

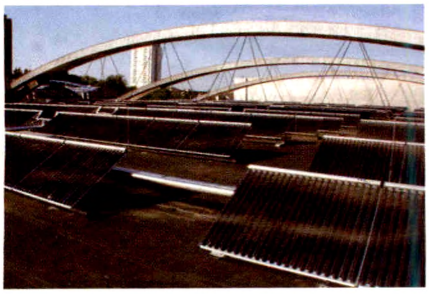
Aqua2use Graywater System from Water Wise Group collects water from the shower, laundry, lavatory sinks, and bath and channels it through a four-stage filtration system into a 21-gallon polyethylene tank to create water suitable for outdoor irrigation. The system's control box automatically triggers the pump when the tank is filled, to distribute the water to irrigation lines; it can also be configured in some situations to rely exclusively on gravity flow instead of a pump.

Cypress Envirosystems' Analog-to-Digital Wireless Thermostat



Cypress Envirosystems' analog-to-digital wireless thermostat allows controls in existing buildings to be fully digitised to achieve significant energy savings. They effectively bring older buildings at par with those in the 21st century, allowing zone-level control and remote management options along with lighting controls and wireless monitoring systems for mechanical equipment. The controls fully integrate with building automation systems and can be installed as a retrofit in less than 30 minutes.

Ritter XL Solar Thermal System

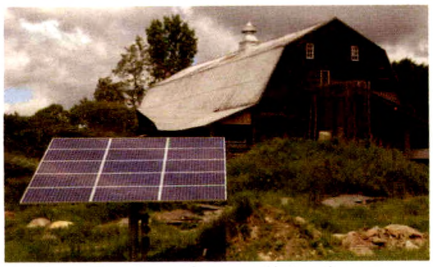


The Ritter XL solar thermal system from Regasol USA combines three unique technologies—advanced evacuated tubes, compound parabolic reflectors, and water as a heat-transfer fluid—to create large-scale solar thermal systems for use in commercial, multifamily, or industrial applications that have high hot-water demand. The complex systems use a sophisticated freeze-prevention mechanism and can provide high-temperature water year-round, even in cold climates.

Mitsubishi Ductless Heat Pumps and Variable-Refrigerant-Flow Systems with Tenant Submetering

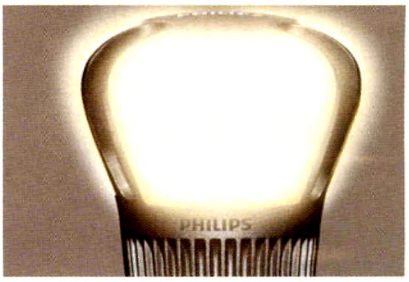
Mitsubishi ductless heat pumps and variable-refrigerant-flow systems with tenant submetering supply efficient heating and cooling for residential and commercial applications with a unique tenant submetering feature. Mitsubishi Electric has been a market leader of the air-source heat pump revolution in recent years–providing efficient systems that significantly outperform older, unitary heat pumps, even at low outdoor temperatures.

AllSun Trackers



AllSun Trackers from AllEarth Renewables combine photovoltaic collectors, inverters, and controls with a ground-mounted tracker that uses GPS to follow the sun precisely as it moves across the sky in order to maximise the amount of light hitting the panels. Upon 'waking' in the morning, they tilt to the north to dump accumulated snow, and in high wind they move to a 'stow' position parallel with the ground to minimise wind resistance.

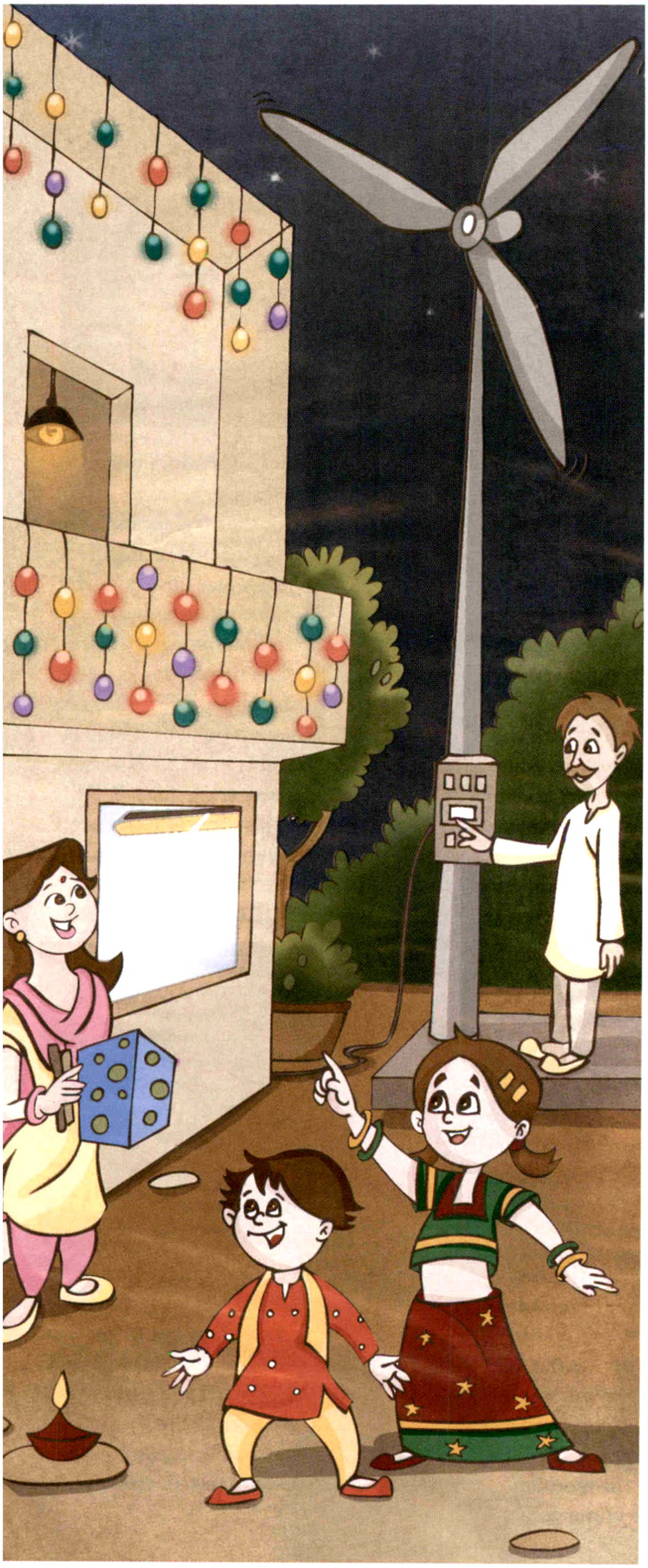
Philips EnduraLEDs



Philips EnduraLEDs from Philips Lighting were engineered as a replacement for the 60W incandescent light bulb and is the first such LED bulb to be Energy Star-qualified. The bulb has a unique yellow appearance when turned off but provides a warm, white light when turned on; its colour temperature is comparable to that of a 60W incandescent bulb. This bulb is currently available in a 12.5W version with a colour rendering index (CRI) of 80, but Philips plans to introduce a 10W version with a CRI of 90 in 2012.

Light Weight Clay Roofing

Lightweight Clay Roofing tiles are kiln-fired for unsurpassed aesthetics that will not fade. They are 10 per cent recyclable, have cool roof rated colours, can be locally sourced and their 50 per cent recycled content helps maximise LEED credits without compromising aesthetics, performance or cost.



Akshay Urja Aur Hum

Tune into Akshay Urja aur Hum, from July 11th. Full of information, technical knowhow, prizes and fun - the Ministry of New and Renewable Energy, all set to usher in a clean revolution.

FM Rainbow Stations

Sr. No.	Stations	Language	Monday Time (hrs.)	Wednesday Time (hrs.)	Friday Time (hrs.)
1.	Bangalore	Kannada	09.45	09.45	09.45
2.	Chennai	Tamil	09.45	09.45	09.45
3.	Coimbatore	Tamil	07.45	07.45	07.45
4.	Cuttack	Oriya	20.30	20.30	20.30
5.	Delhi	Hindi	09.00	09.00	09.00
6.	Hyderabad	Telegu	08.45	08.45	08.45
7.	Jalandhar	Punjabi	08.45	08.45	08.45
8.	Kanpur	Hindi	09.00	09.00	09.00
9.	Kochi	Malayalam	07.00	07.00	07.00
10.	Kodaikanal	Tamil	09.30	09.30	09.30
11.	Kolkata	Bengali	08.45	08.45	08.45
12.	Lucknow	Hindi	07.02	07.02	07.02
13.	Mumbai	Marathi	07.45	07.45	07.45
14.	Panaji	Hindi	07.45	07.45	07.45
15.	Puducherry	Tamil	09.00	09.00	09.00
16.	Tiruchirapalli	Tamil	09.45	09.45	09.45
17.	Vijayawada	Telegu	10.15	10.15	10.15
18.	Vishakhapatnam	Telegu	09.30	09.30	09.30

FM (Gold) Stations

Sr. No.	Stations	Language	Monday Time (hrs.)	Wednesday Time (hrs.)	Friday Time (hrs.)
1.	Chennai	Tamil	08.45	08.45	08.45
2.	Delhi	Hindi	10.30	10.30	10.30
3.	Kolkata	Bengali	09.45	09.45	09.45
4.	Mumbai	Marathi	07.00	07.00	07.00

STATIC POWER

Electrical charges can be negative (-) or positive (+). Opposite charges attract each other while similar charges repel each other. As electrical charges build up on a material, it creates static electricity.

Background:

When coal is burned in a power plant, small particles of pollution called soot are produced. Static electricity can be used to capture soot before it leaves the power plant.

Question

Can a mixture of salt, sugar and pepper be separated using static electricity?

Possible Hypotheses:

A mixture of salt, sugar and pepper can/cannot be separated.

Materials

Sugar, salt, and pepper, small plate, plastic comb, piece of wool

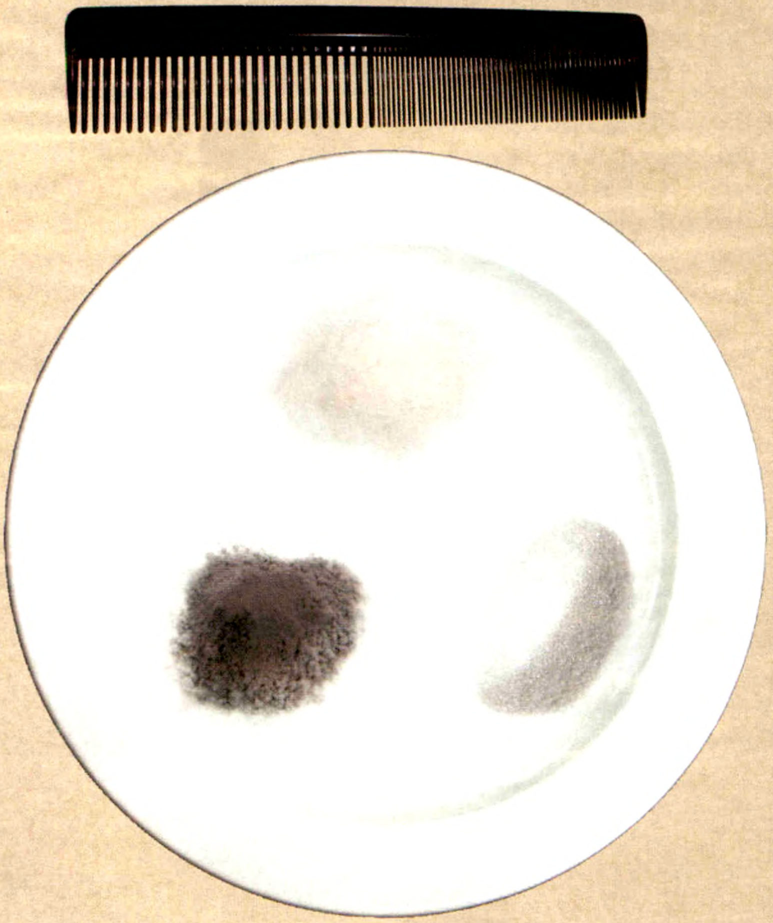
Procedure

1. Stroke the comb with wool to give it an electric charge.
2. Put small amounts of sugar, salt, and pepper on a plate. Do not mix them together. Beginning a few inches above the plate, move the comb closer to the particles. Observe to see if one type of particle reacts before the others.
3. Record your observations.
4. Repeat the experiment with the salt, sugar, and pepper mixed together.

What do you see?

Are the particles attracted to the comb at different heights above the plate? Can you separate a mixture of salt, sugar, and pepper using static electricity? Do you think static electricity could be used to clean the air at a coal-burning power plant?

Send your answers to the **Editor** and see your name specially flashed on this page.



Source : www.ehow.com

←→ Website

Algae Biodiesel Website

www.making-biodiesel-books.com

Algae biodiesel fuels are now becoming popular as an alternative fuel to power vehicles. The interest has largely been due to the rising fuel costs of gas and diesel combined with the search for a sustainable source of energy. The new Algae Biodiesel website hopes to help people find the information they are looking for. The main issue facing those interested in producing their own algae biofuels is the lack of information. The website will be able to educate people about algae production for biodiesel.

Geothermal Professionals

www.geothermalprofessionals.com

Geothermal Professionals is an Ohio based, fully integrated and licensed geothermal systems installer, designed to handle all geothermal needs. The website promises to be a one-stop shop for all geothermal energy needs.

Science Omega

www.scienceomega.com

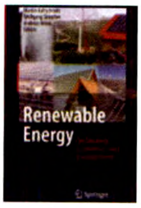
Science Omega showcases news, features and opinions from the fields of science, technology, engineering and mathematics (STEM). The website includes regular news updates to keep one abreast of the latest developments, with insightful feature articles from the best and brightest that the scientific community has to offer. Informed opinion pieces stimulate vigorous debate, and there is the weekly Science Omega Podcast in which the editorial team takes a light-hearted look at all things STEM-related.

Energy:

Production, Conversion, Storage, Conservation, and Coupling

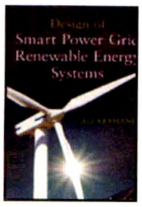
By: **Yasar Demirel**
Hard Cover: 746 pages
Cost: 132.65 Euro
Publisher: Springer London 2012
ISBN No- 13: 9781447123712

This book provides a good understanding on the sustainable use of energy in various processes and is an integral part of engineering and scientific studies. It gives a thorough understanding of five main areas of energy and includes 130 examples and over 600 practice problems on topics like energy production and conversion in important physical, chemical, and biological processes, conservation of energy and its impact on sustainability, various forms of energy storage, and energy coupling and bioenergetics in living systems. A solution manual for the practice problems of the textbook is also offered for the instructor.



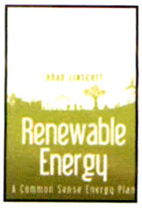
Renewable Energy: Technology, Economics and Environment

By: **Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese**
Hard Cover: 596 Pages
Cost: USD 87
Publisher: Springer, 2010
ISBN: 3642089941, 9783642089947



Design of Smart Power Grid Renewable Energy Systems

By: **Ali Keyhni**
Hard Cover: 400 pages
Cost:USD 108.75
Publisher: Wiley-IEEE Press, 2011
ISBN: 978-0470627617



Renewable Energy: A Common Sense Energy Plan

By: **Brad Linscott**
Hard Cover: 252 Pages
Cost: USD 123.00
Publisher: Tate Publishing 2011
ISBN: 978-1-61777-608-3

Renewable Energy: Green Power for a Modern World

By: **Holly Simon**
Hard Cover: 268 Pages
Cost: USD 21.09
Publisher: Webster's Digital Services, 2011
ISBN: 978-1241156763

National

7-10 August 2012	Bio Diversity Asia 2012, Place: JN Tata Auditorium, IISc Campus, Bengaluru, Organiser: Biodiversity Asia 2012, Contact: 91 80 23635555 or SCBasiasecretariat@atree.org, Website: www.scbasia2012.org
21 August 2012	Global Solar Water Heating Market Transformation and Strengthening Initiative : India Country Programme, Place: Vigyan Bhavan, New Delhi, Organiser: UNDP/GEF, Contact: 011 46532333, info.in@undp.org, Website: www.in.undp.org
29-1 August-September 2012	International Conference on Advances in Electrical Engineering and Renewable Technologies, Place: Puducherry, India, Organiser: Rajiv Gandhi College of Engineering and Technology, Contact: Mr.A.Srinivassan +91-9894357018 icaeert@rgcetpdy.ac.in, Website: www.rgcetpdy.ac.in
6-7 September 2012	Wind Power Development forum India, Place: New Delhi, Organiser : Wind Power energy Update, Contact: +44 (0) 20 7375 7516 or will@windenergyupdate.com, Website: www.windenergyupdate.com
14-15 September 2012	International Conference on Biodiversity & Sustainable Energy Development, Place: Hyderabad International Convention Center, India, Organiser : OMICS Group, Contact: 650 268 9744 or biodiversity2012@omicsonline.org, Website: www.omicsonline.org

International

21-23 August 2012	The 4th China Guangzhou International Solar Photovoltaic Exhibition 2012, Place: China Import and Export Fair Pazhou Complex- Area A, Organiser: Solar Energy Industries Association (SEIA) and The Solar Electric Power Association (SEPA), United States, Contact: 541 575 3633, Website: www.pvguangzhou.com
04-05 September 2012	Chilean International Renewable Energy Congress Place: Santiago, Chile, Organiser: Green Power Conferences, Contact: Natalia Valencia +44 (0)203 384 6214, natalia.valencia@greenpowerconferences.com, Website: www.greenpowerconferences.com
05-06 September 2012	Awea Regional Wind Energy Summit – New England, Place: Portland, Maine, Organiser: American Wind Energy Association, Contact: 202 383 2500, windmail@awea.org 83 2500, Website: www.awea.org
10-13 September 2012	Solar Power International 2012, Place: Orlando, Florida, Organiser: Solar Energy Industries Association (SEIA) and The Solar Electric Power Association (SEPA), United States, Contact: Jennifer Samuels 866 229 3691, spi@experient-inc.com Website: www.solarpowerinternational.com

Renewables, Global Status Report

Selected Renewable Energy Indicators

	2008	2009	2010
Global new investment in new renewable energy (annual; figures in billion USD)	130	160	211
Renewables power capacity (existing, not including hydro; figures in GW)	200	250	312
Renewables power capacity (existing, including hydro; figures in GW)	1150	1230	1320
Hydropower capacity (existing; figures in GW)	950	980	1010
Wind power capacity (existing; figures in GW)	121	159	198
Solar PV capacity (existing; figures in GW)	16	23	40
Solar PV cell production (annual; figures in GW)	6.9	11	24
Solar hot water capacity (existing; figures in GW)	130	160	185 GWth
Ethanol production (annual; figures in billion litres)	67	76	86
Biodiesel production (annual; figures in billion litres)	12	17	19
Countries with policy targets	79	89	96
States/provinces/countries with feed-in policies*	71	82	87
States/provinces/countries with RPS/quota policies	60	61	63
States/provinces/countries with bio-fuels mandates	55	57	60

- In the United States, renewable energy accounted for about 10.9 per cent of domestic primary energy production indicating an increase of 5.6 per cent when compared to 2009.
- China added an estimated 29 GW of grid-connected renewable capacity, for a total of 263 GW - an increase of 12 per cent in comparison to 2009.
- At least 20 countries in the Middle East, North Africa, and sub-Saharan Africa have active renewable energy markets.
- Several countries met higher shares of their electricity demand with wind power in 2010, including Denmark (22 per cent), Portugal (21 per cent), Spain (15.4 per cent), and Ireland (10.1 per cent).
- China attracted more than a third of global investment in renewable energy companies during 2010, making it the leader in the second year, consecutively.
- Germany met 11 per cent of its total final energy consumption with renewable sources, which accounted for 16.8 per cent of electricity consumption, 9.8 per cent of heat production (mostly from biomass), and 5.8 per cent of transport fuel consumption. Wind power accounted for nearly 36 per cent of renewable generation, followed by biomass, hydropower, and solar photovoltaics (PV).

Notes: * Feed-in policies total for 2010 also includes early 2011.

Source: Renewable 2011, Global Status Report. www.ren21.net